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Cooper

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(54) **METHOD FOR MELTING SOLID METAL**

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(58) **Field of Classification Search**

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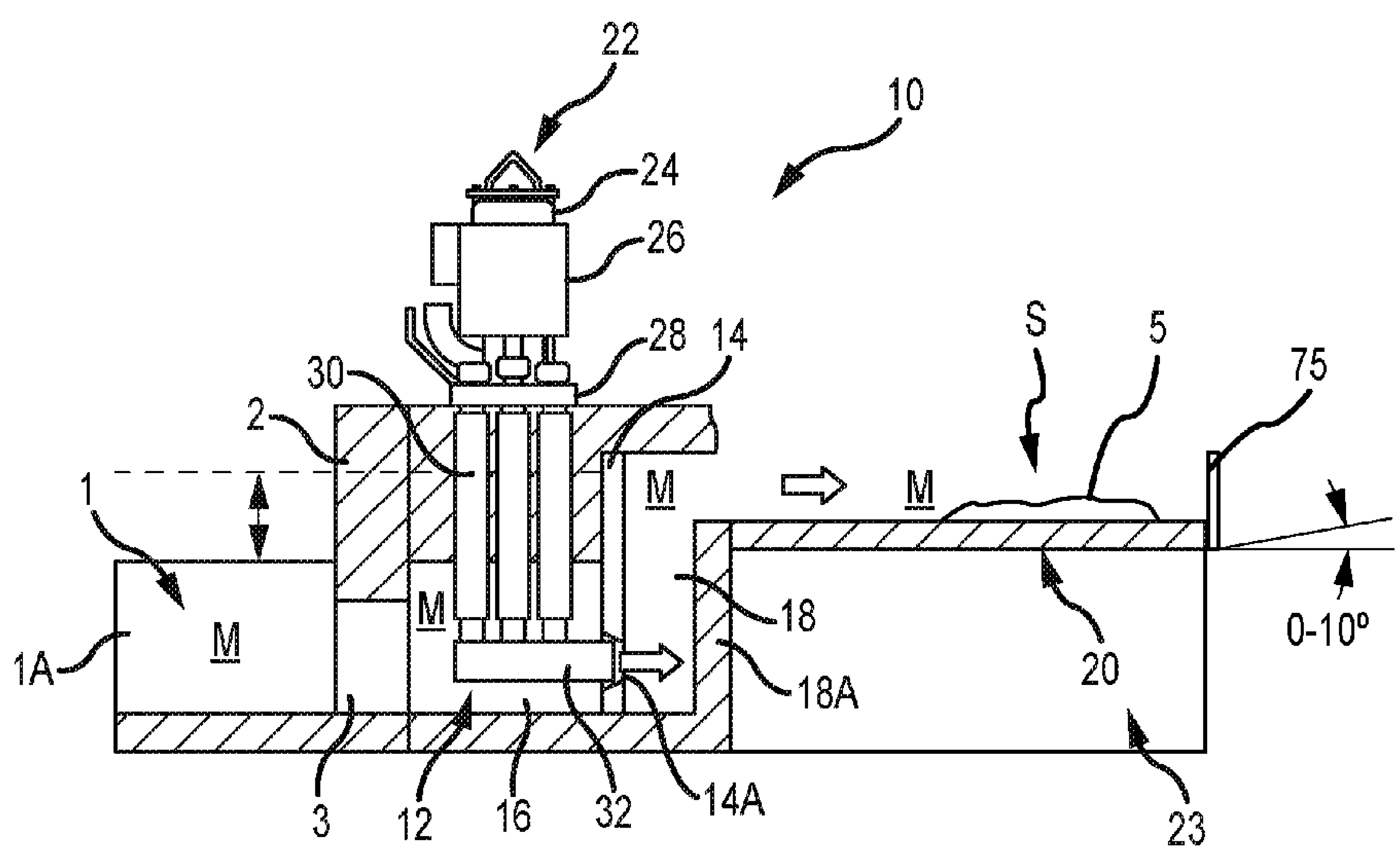
(57) **ABSTRACT**

A scrap melting system and method includes a vessel that is configured to retain molten metal and a raised surface about the level of molten metal in the vessel. Solid metal is placed on the raised surface and molten metal from the vessel is moved upward from the vessel and across the raised surface to melt at least some of the solid metal. The molten metal is preferably raised from the vessel to the raised surface by a molten metal pumping device or system. The molten metal moves from the raised surface and into a vessel or launder.

20 Claims, 13 Drawing Sheets



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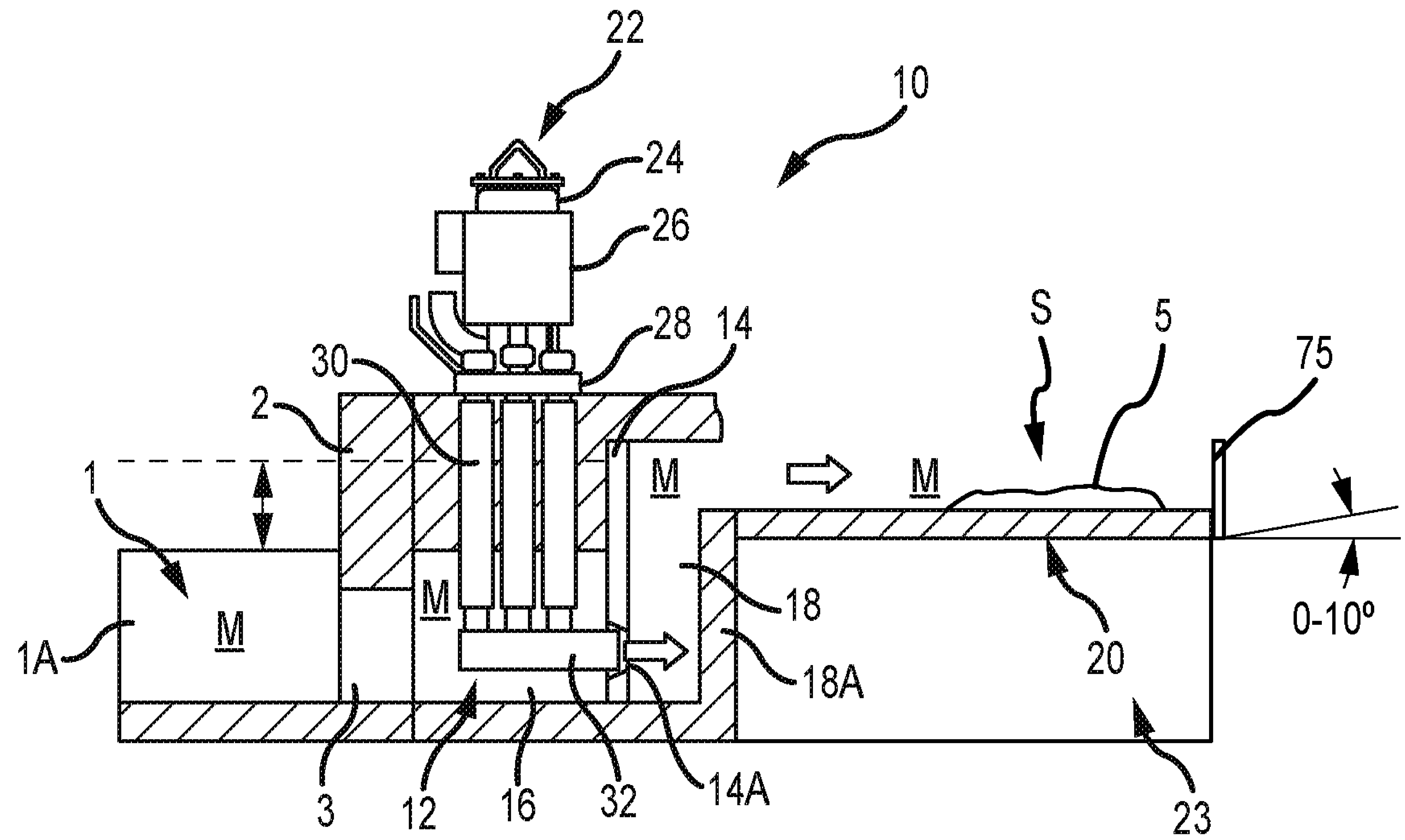
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14A
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FIG.1

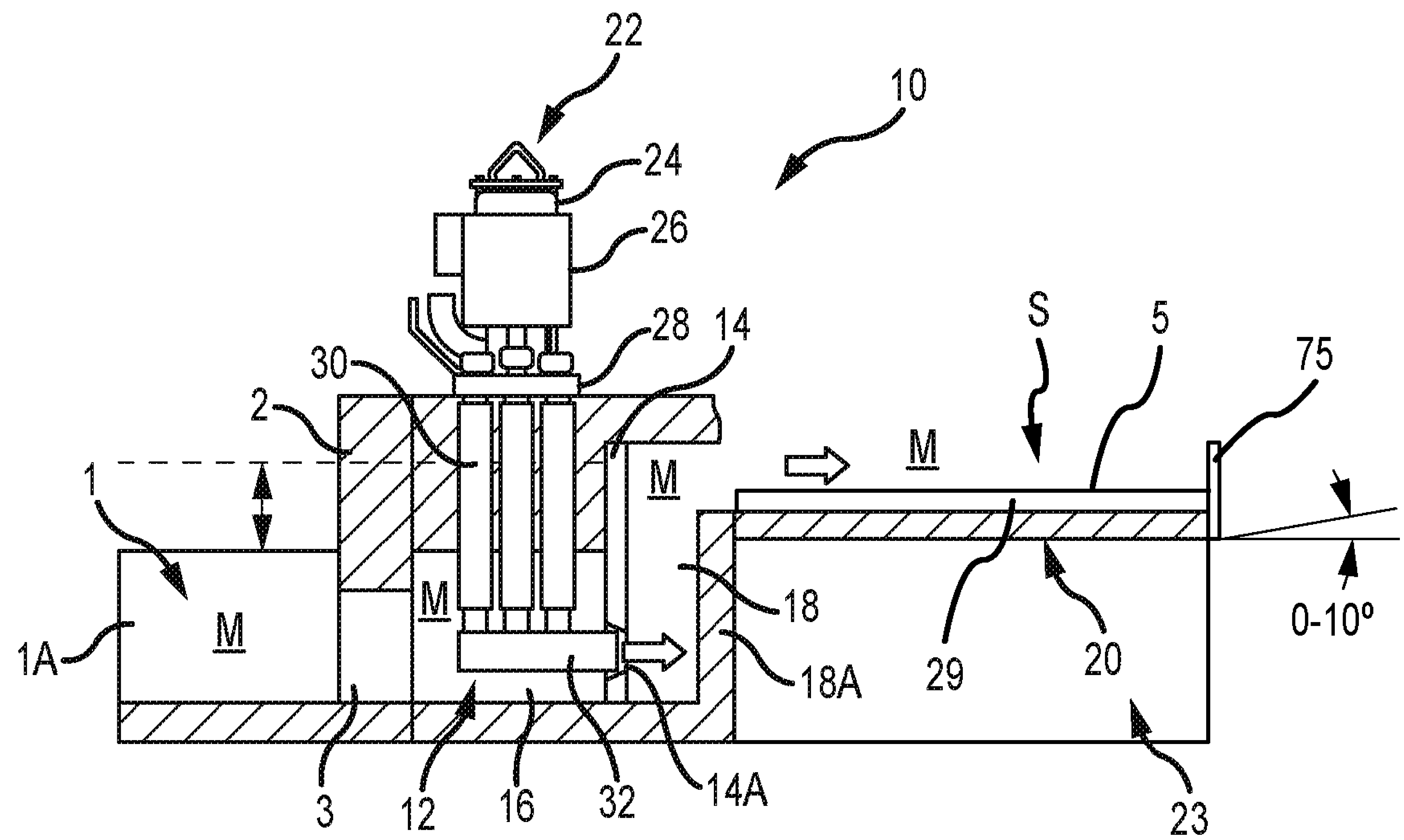
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FIG.1A

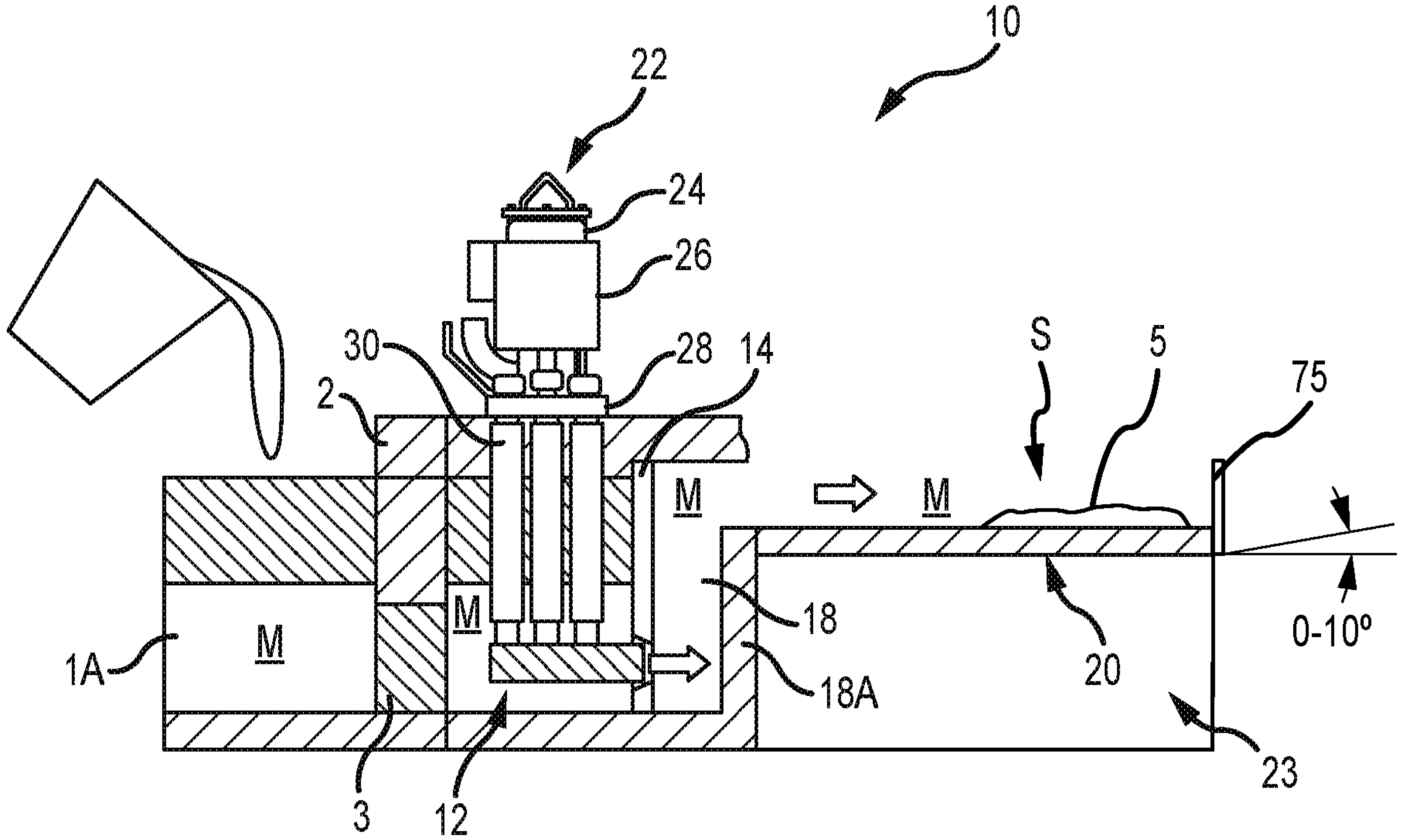
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FIG.2

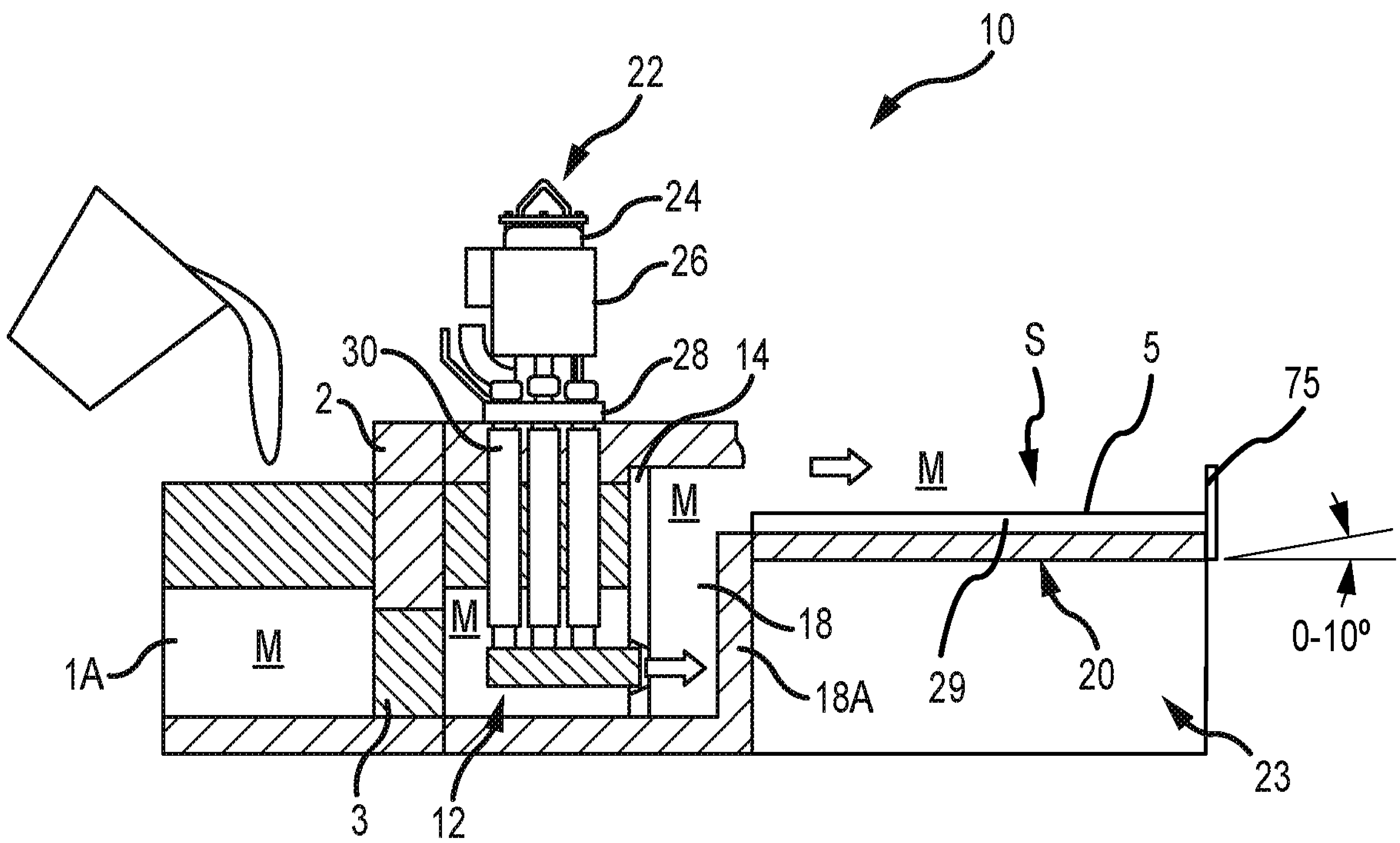
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FIG.2A

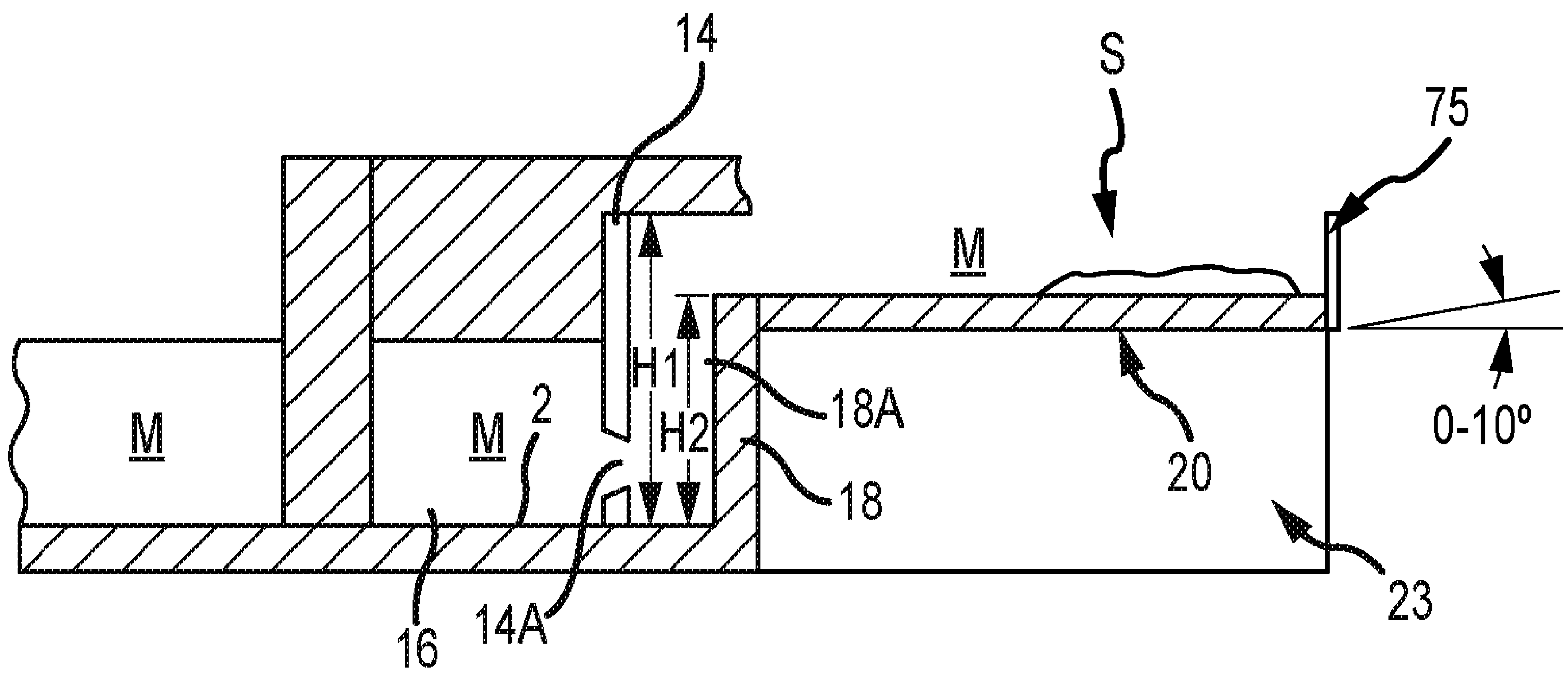

FIG.2B

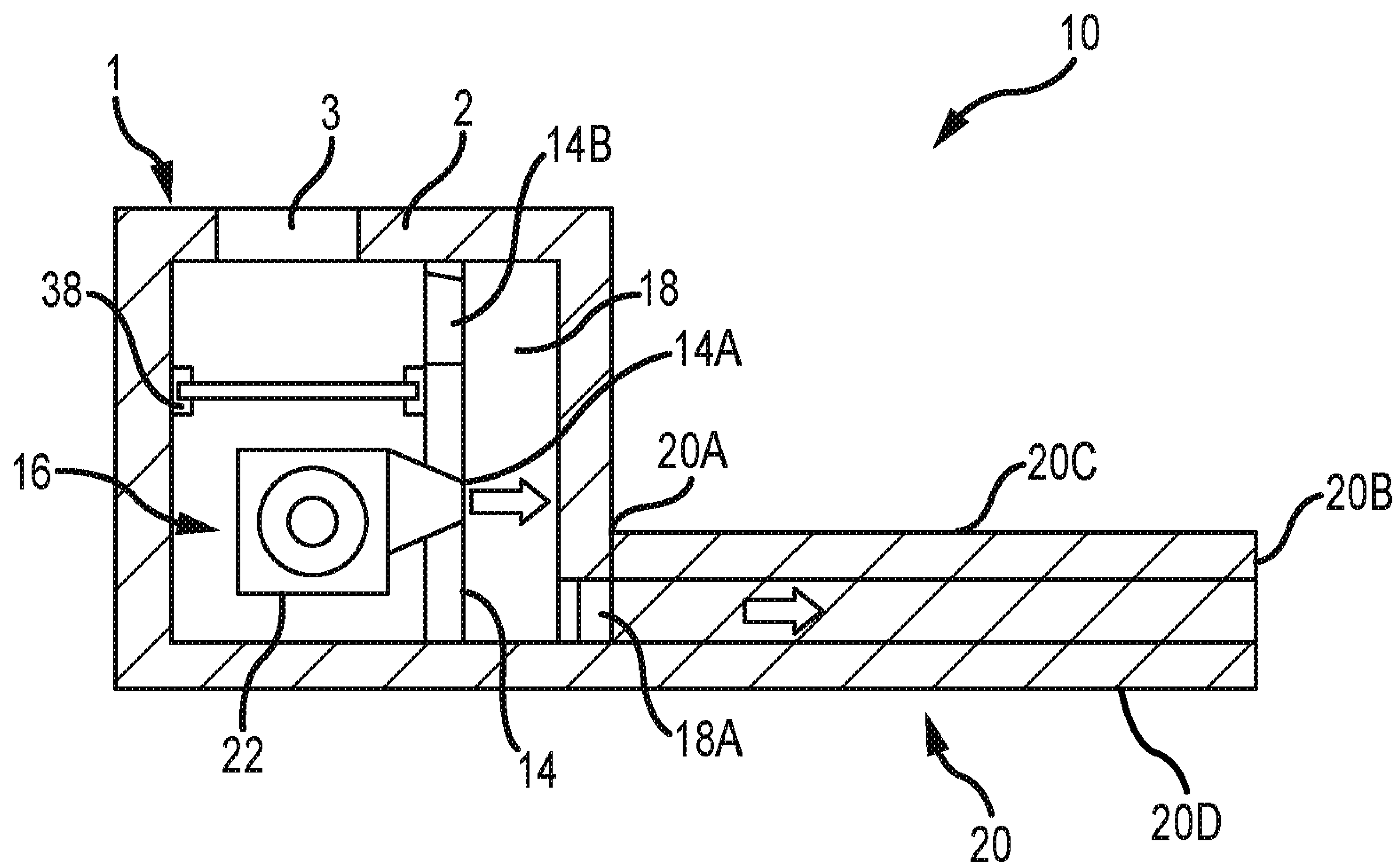

FIG.3

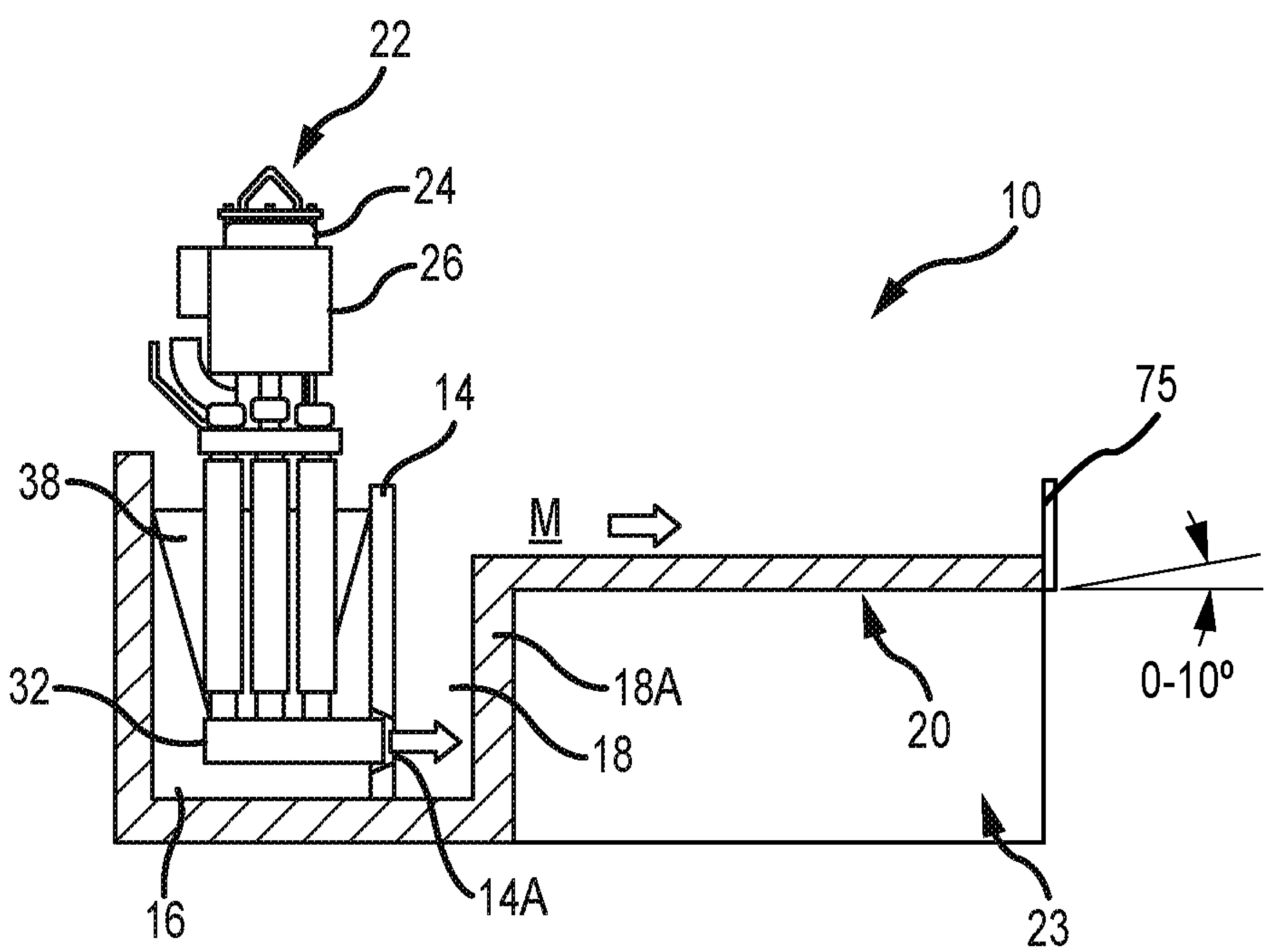

FIG.3A

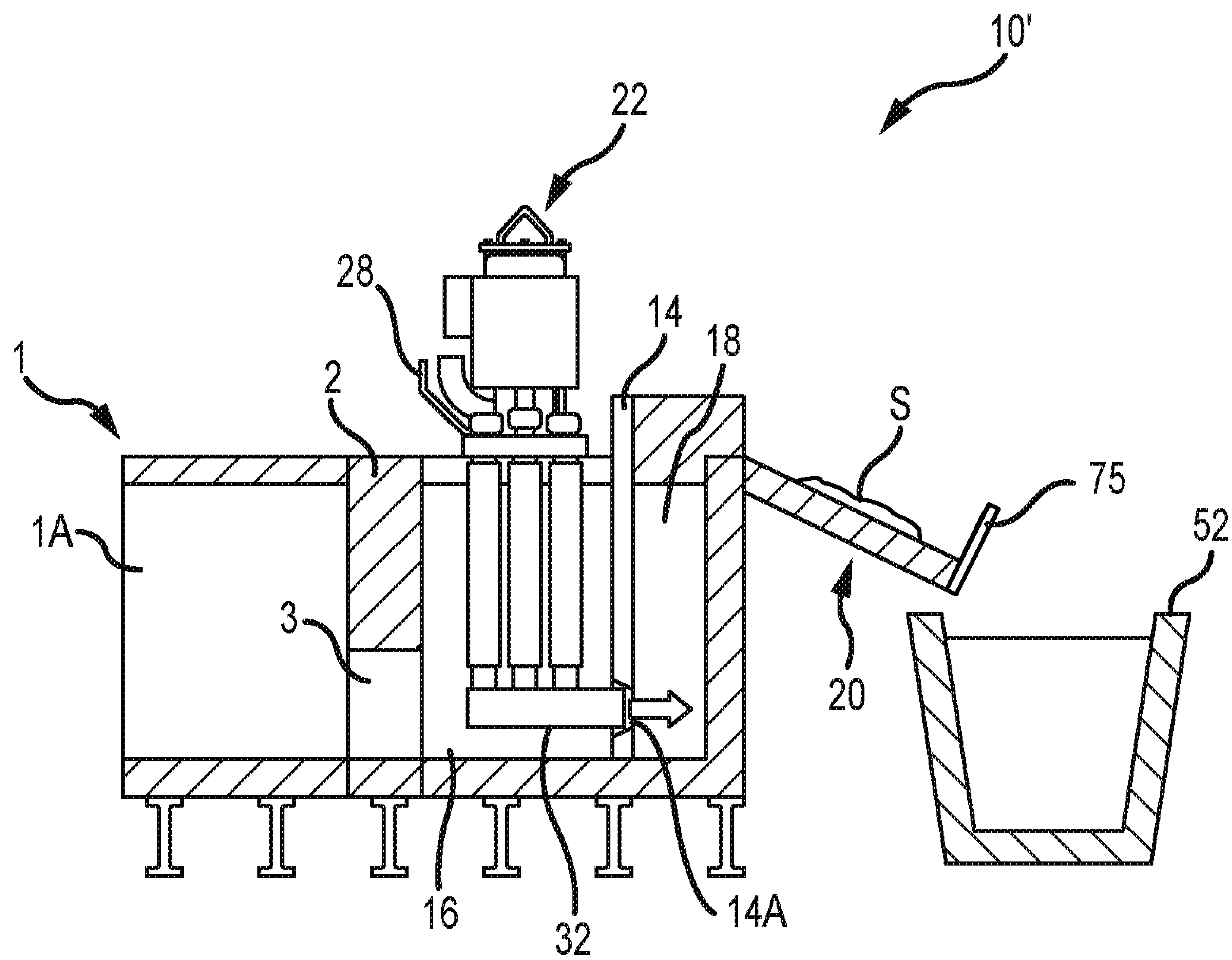

FIG.4

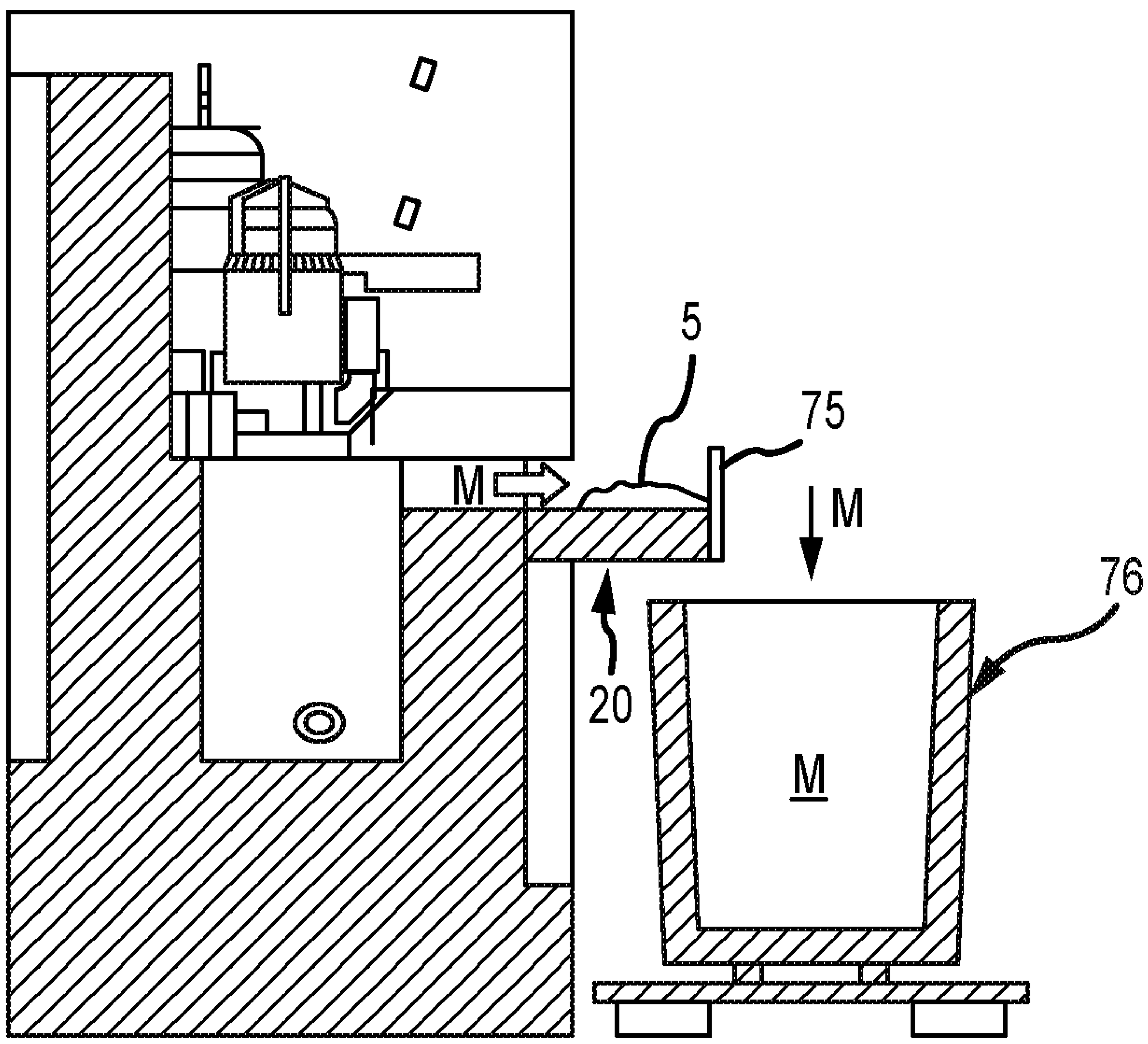

FIG.5

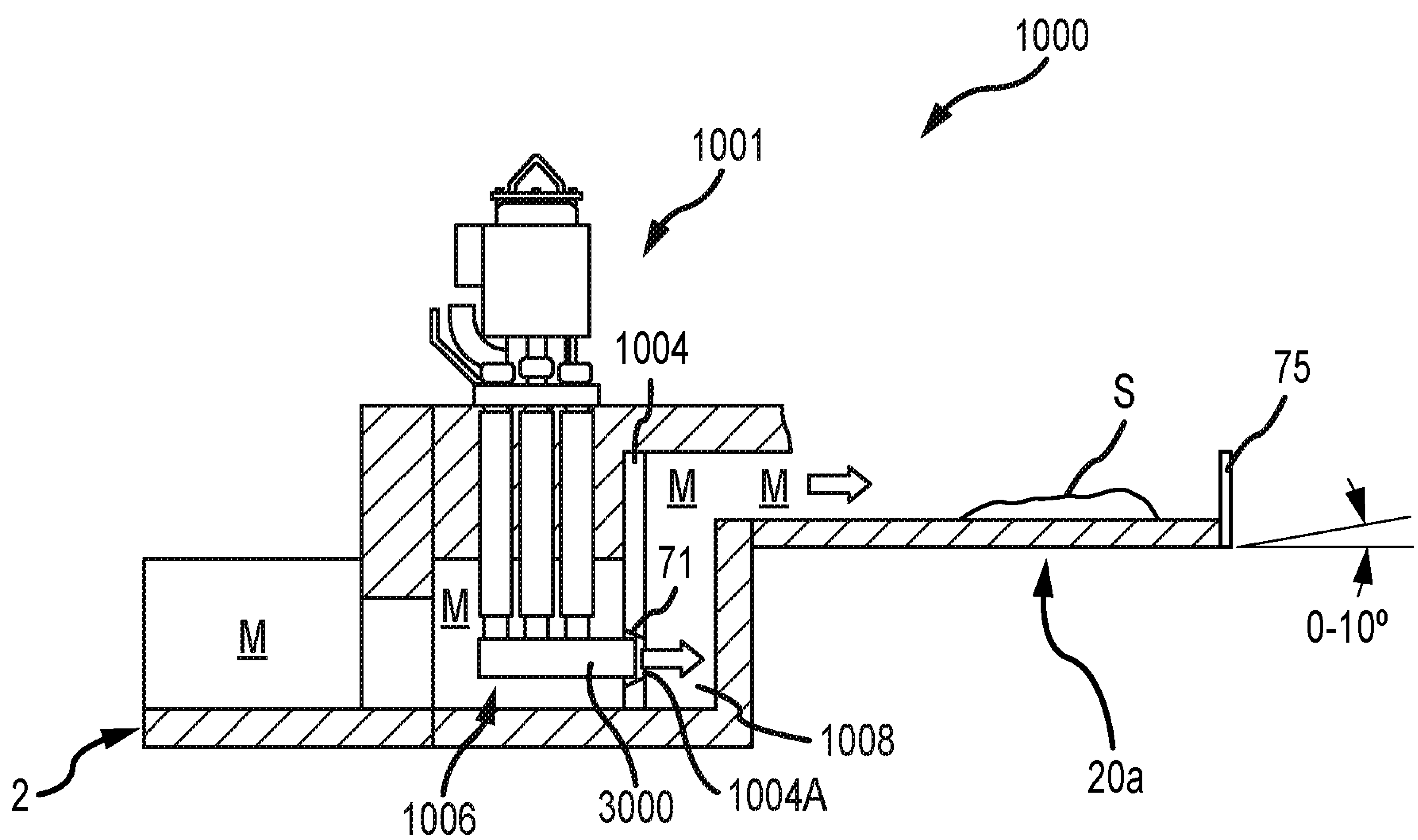

FIG.6

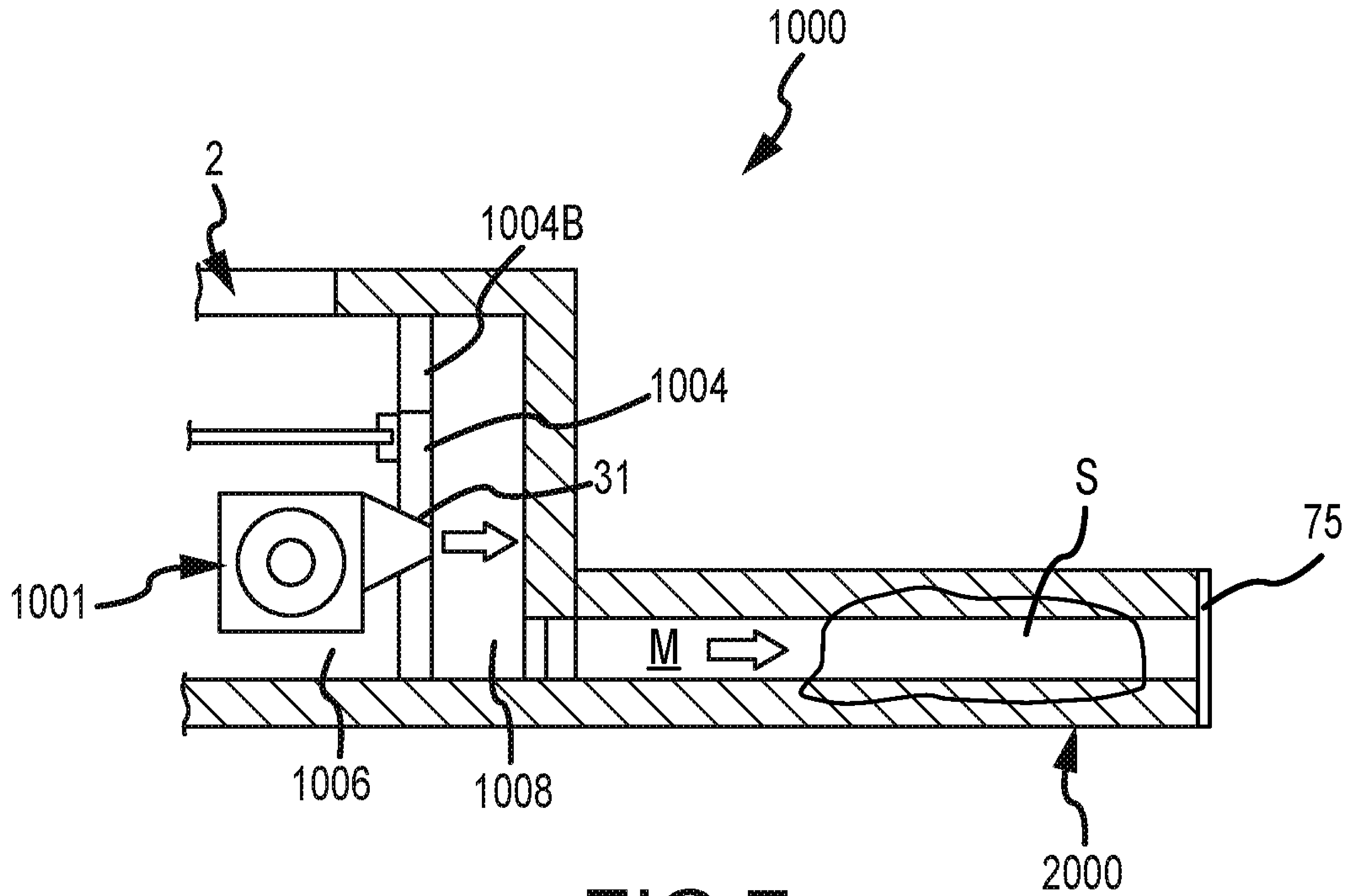
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FIG.7

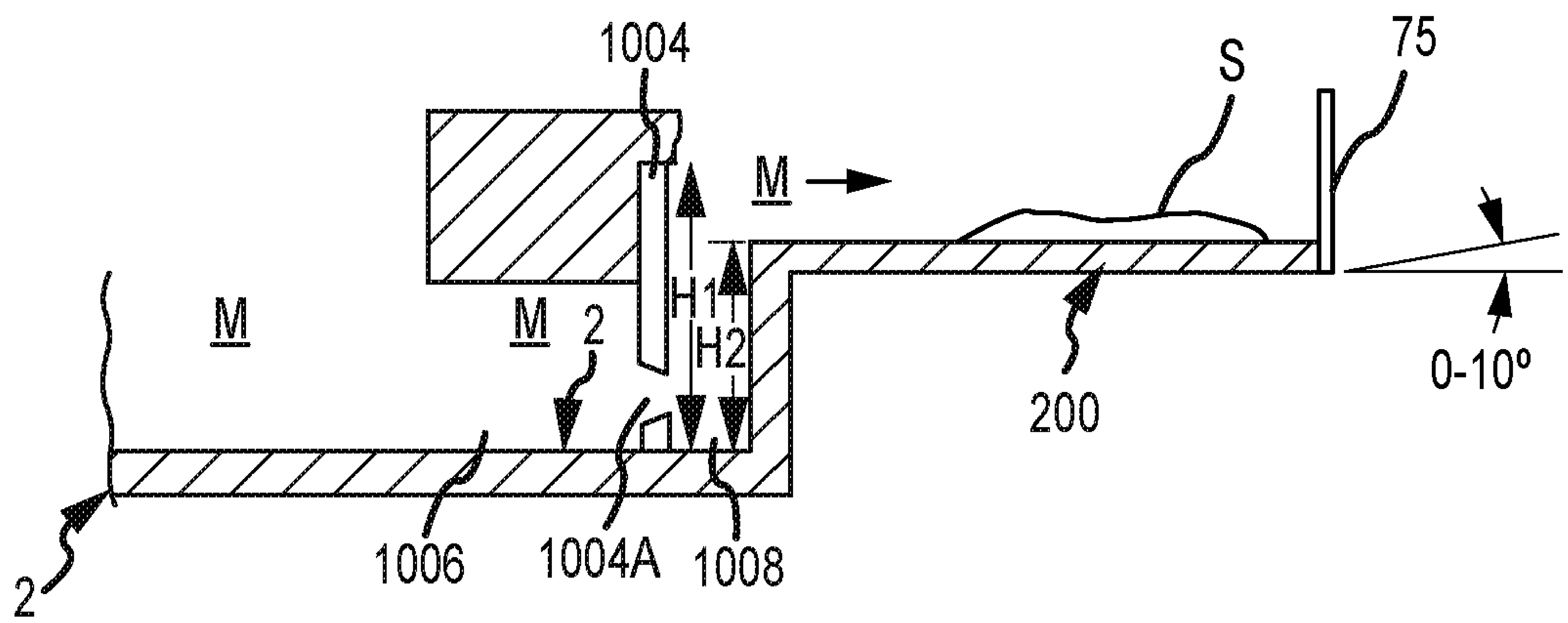
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FIG.8

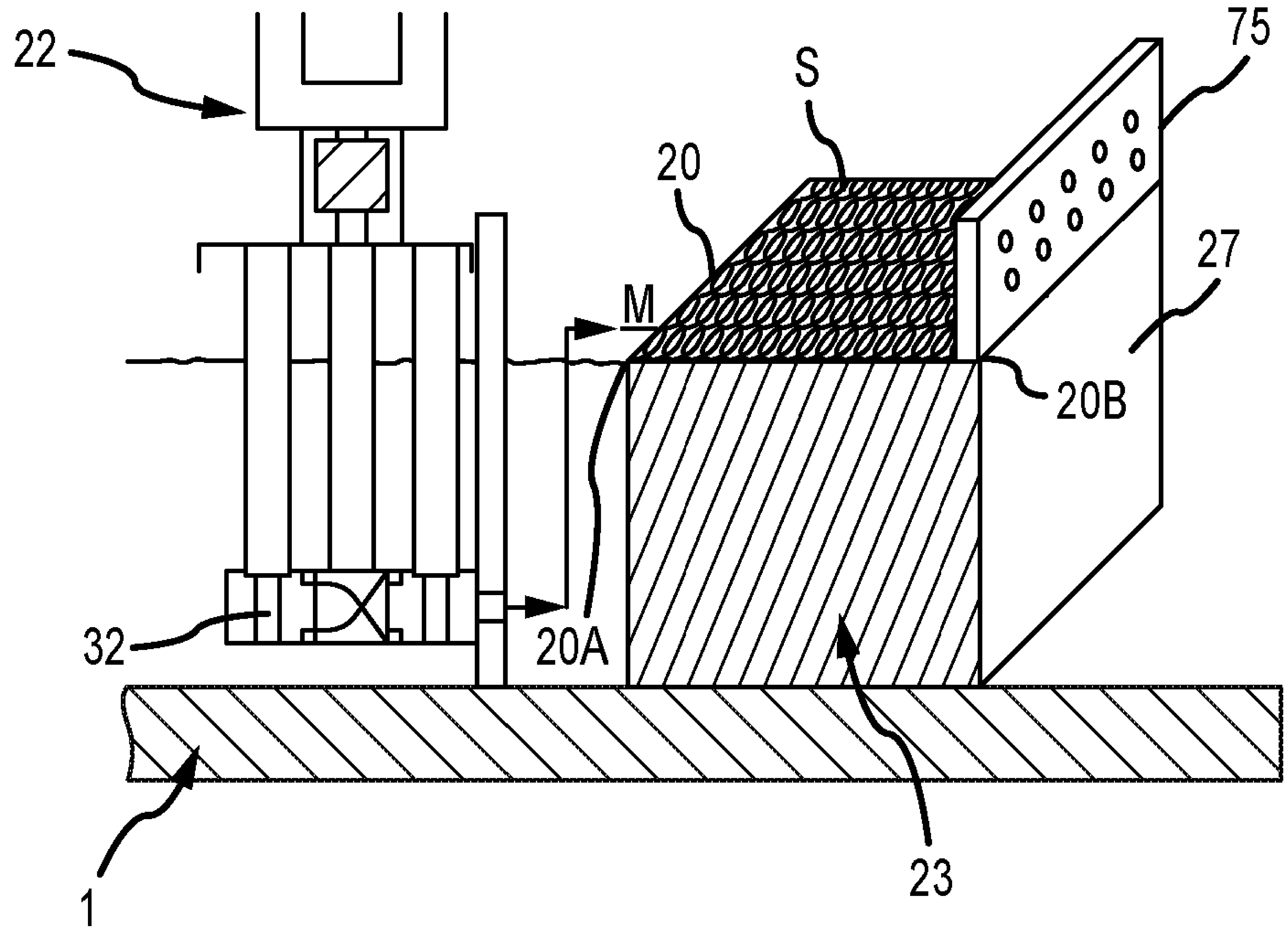
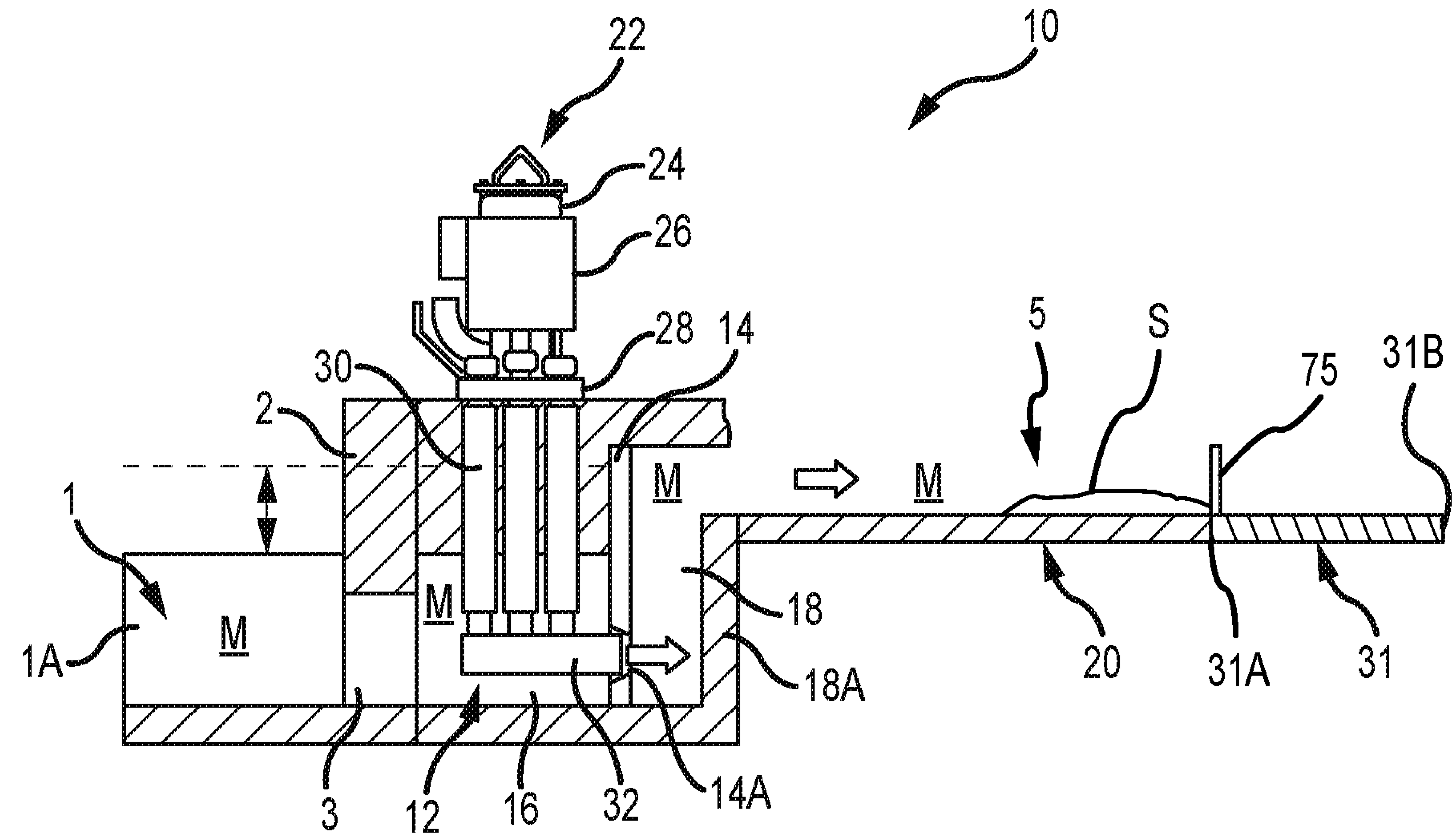


FIG.9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M
M
5
S
75
31B
1A
18
18A
20
31A
31
3
12
16
32
14A

FIG.10

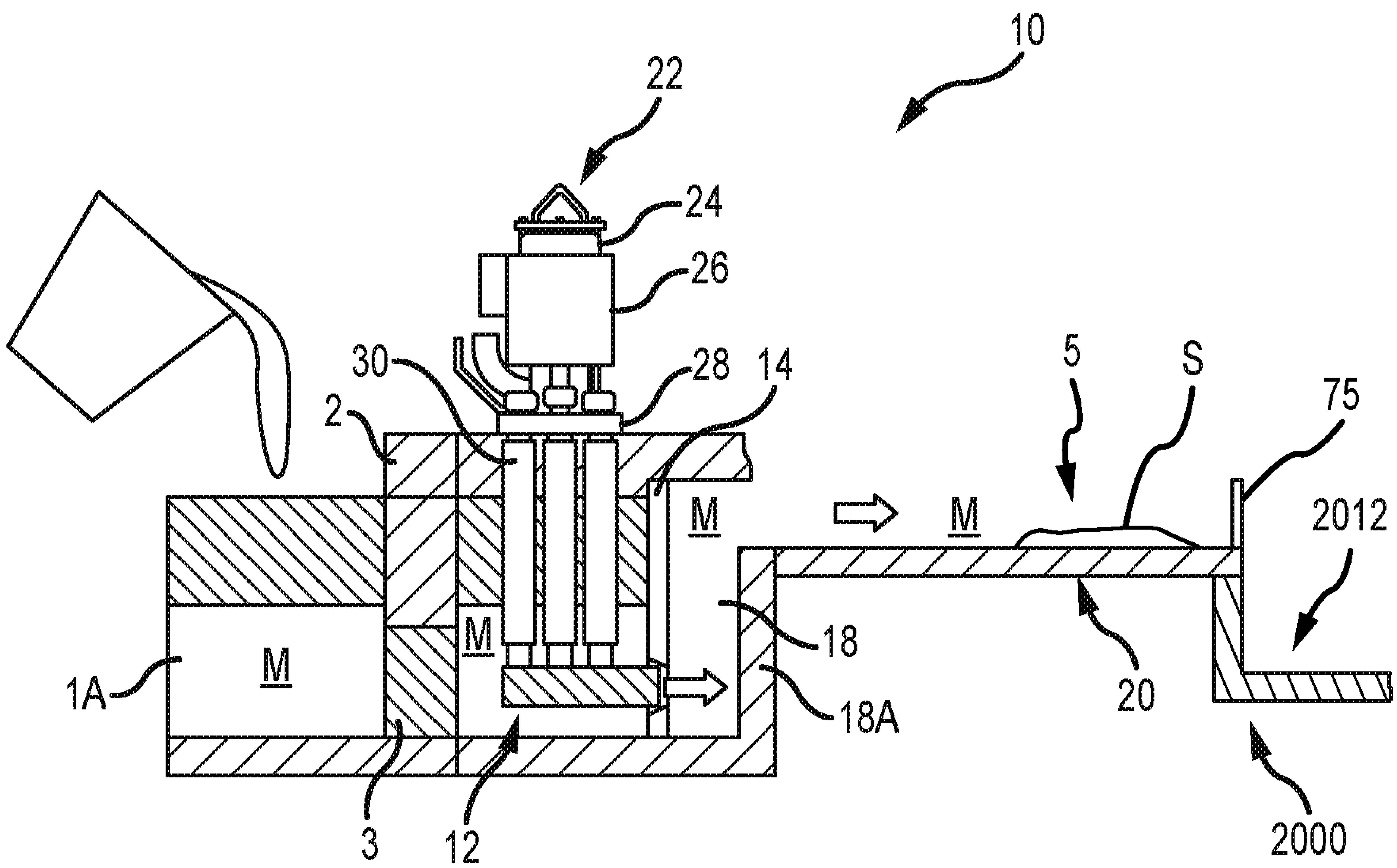
10
22
24
26
30
28
14
2
M
M
5
S
75
2012
M
1A
M
18
18A
20
3
12
2000

FIG.11

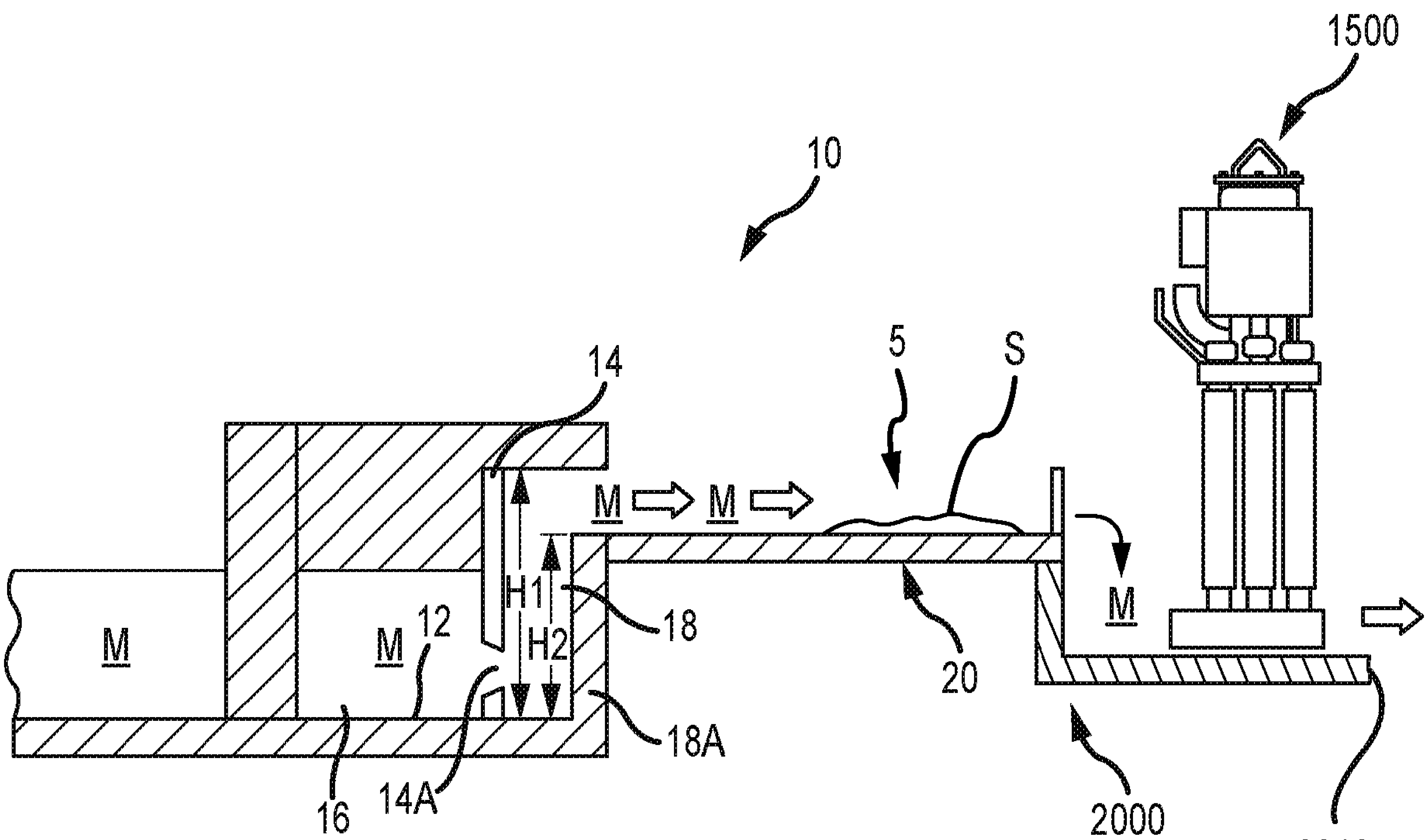

FIG.12

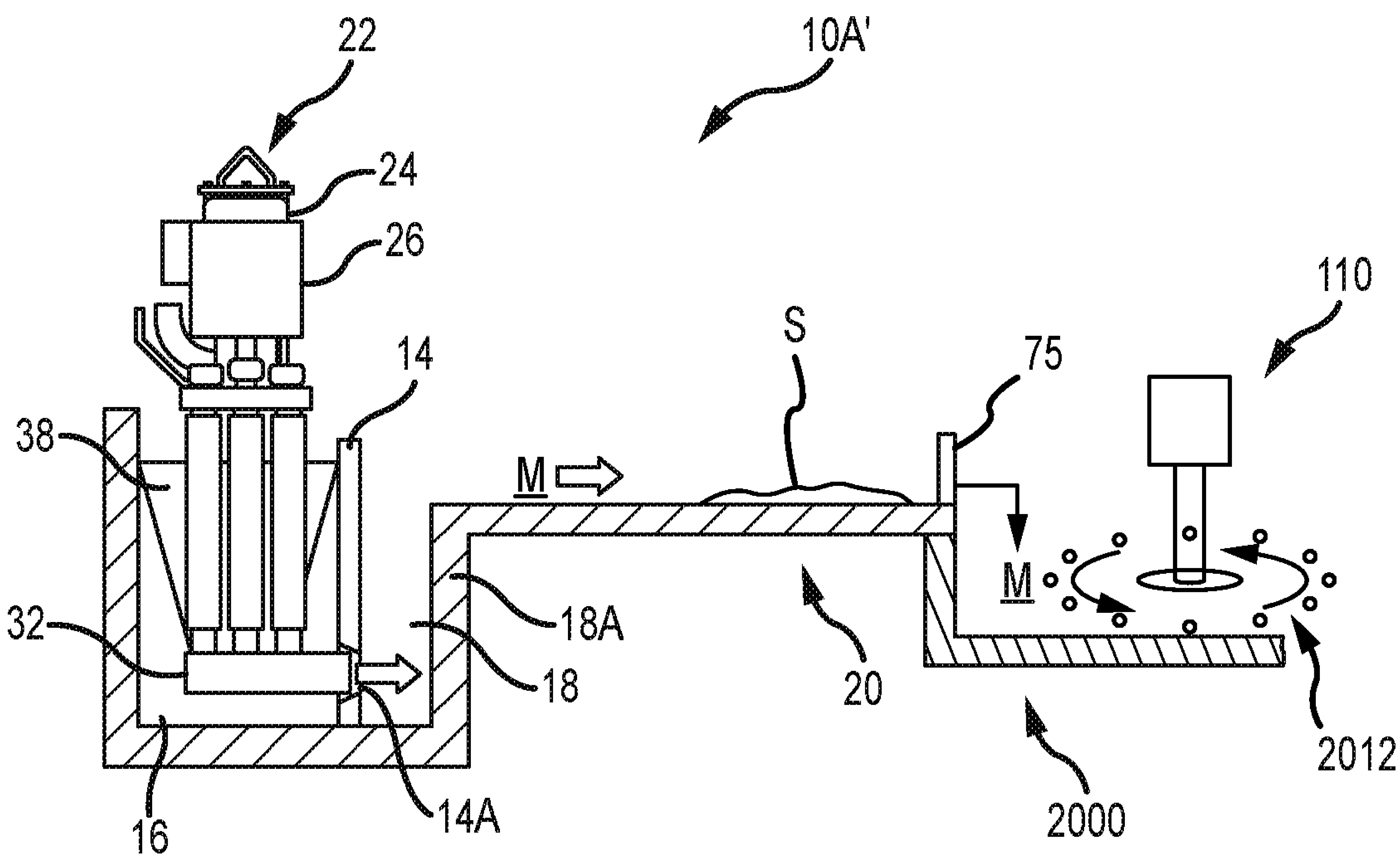

FIG.13

METHOD FOR MELTING SOLID METAL

CROSS REFERENCE TO RELATED APPLICATIONS

This Application claims priority to and incorporates by reference: (1) U.S. Provisional Patent Application Ser. No. 62/849,787 filed May 17, 2019 and entitled MOLTEN METAL PUMPS, COMPONENTS, SYSTEMS AND METHODS, and (2) U.S. Provisional Patent Application Ser. No. 62/852,846 filed May 24, 2019 and entitled SMART MOLTEN METAL PUMP.

BACKGROUND OF THE INVENTION

As used herein, the term “molten metal” means any metal or combination of metals in liquid form, such as aluminum, copper, iron, zinc and alloys thereof. The term “gas” means any gas or combination of gases, including argon, nitrogen, chlorine, fluorine, Freon, and helium, which are released into molten metal.

Known molten-metal pumps include a pump base (also called a housing or casing), one or more inlets (an inlet being an opening in the housing to allow molten metal to enter a pump chamber), a pump chamber of any suitable configuration, which is an open area formed within the housing, and a discharge, which is a channel or conduit of any structure or type communicating with the pump chamber (in an axial pump the chamber and discharge may be the same structure or different areas of the same structure) leading from the pump chamber to an outlet, which is an opening formed in the exterior of the housing through which molten metal exits the casing. An impeller, also called a rotor, is mounted in the pump chamber and is connected to a drive system. The drive shaft is typically an impeller shaft connected to one end of a motor shaft, the other end of the drive shaft being connected to an impeller. Often, the impeller (or rotor) shaft is comprised of graphite and/or ceramic, the motor shaft is comprised of steel, and the two are connected by a coupling. As the motor turns the drive shaft, the drive shaft turns the impeller and the impeller pushes molten metal out of the pump chamber, through the discharge, out of the outlet and into the molten metal bath. Most molten metal pumps are gravity fed, wherein gravity forces molten metal through the inlet and into the pump chamber as the impeller pushes molten metal out of the pump chamber. Other molten metal pumps do not include a base or support posts and are sized to fit into a structure by which molten metal is pumped. Most pumps have a metal platform, or super structure, that is either supported by a plurality of support posts attached to the pump base, or unsupported if there is no base. The motor is positioned on the superstructure, if a superstructure is used.

This application incorporates by reference the portions of the following publications that are not inconsistent with this disclosure: U.S. Pat. No. 4,598,899, issued Jul. 8, 1986, to Paul V. Cooper, U.S. Pat. No. 5,203,681, issued Apr. 20, 1993, to Paul V. Cooper, U.S. Pat. No. 5,308,045, issued May 3, 1994, by Paul V. Cooper, U.S. Pat. No. 5,662,725, issued Sep. 2, 1997, by Paul V. Cooper, U.S. Pat. No. 5,678,807, issued Oct. 21, 1997, by Paul V. Cooper, U.S. Pat. No. 6,027,685, issued Feb. 22, 2000, by Paul V. Cooper, U.S. Pat. No. 6,124,523, issued Sep. 26, 2000, by Paul V. Cooper, U.S. Pat. No. 6,303,074, issued Oct. 16, 2001, by Paul V. Cooper, U.S. Pat. No. 6,689,310, issued Feb. 10, 2004, by Paul V. Cooper, U.S. Pat. No. 6,723,276, issued Apr. 20, 2004, by Paul V. Cooper, U.S. Pat. No. 7,402,276, issued Jul. 22, 2008, by Paul V. Cooper, U.S. Pat. No. 7,507,367, issued Mar. 24, 2009, by Paul V. Cooper, U.S. Pat. No. 7,906,068, issued Mar. 15, 2011, by Paul V. Cooper, U.S. Pat. No. 8,075,837, issued Dec. 13, 2011, by Paul V. Cooper, U.S. Pat. No. 8,110,141, issued Feb. 7, 2012, by Paul V. Cooper, U.S. Pat. No. 8,178,037, issued May 15, 2012, by Paul V. Cooper, U.S. Pat. No. 8,361,379, issued Jan. 29, 2013, by Paul V. Cooper, U.S. Pat. No. 8,366,993, issued Feb. 5, 2013, by Paul V. Cooper, U.S. Pat. No. 8,409,495, issued Apr. 2, 2013, by Paul V. Cooper, U.S. Pat. No. 8,440,135, issued May 15, 2013, by Paul V. Cooper, U.S. Pat. No. 8,444,911, issued May 21, 2013, by Paul V. Cooper, U.S. Pat. No. 8,475,708, issued Jul. 2, 2013, by Paul V. Cooper, U.S. patent application Ser. No. 12/895,796, filed Sep. 30, 2010, by Paul V. Cooper, U.S. patent application Ser. No. 14/877,988, filed Sep. 8, 2010, by Paul V. Cooper, U.S. patent application Ser. No. 12/853,238, filed Aug. 9, 2010, by Paul V. Cooper, U.S. patent application Ser. No. 14/880,027, filed Sep. 10, 2010, by Paul V. Cooper, U.S. patent application Ser. No. 13/752,312, filed Jan. 28, 2013, by Paul V. Cooper, U.S. patent application Ser. No. 13/756,468, filed Jan. 31, 2013, by Paul V. Cooper, U.S. patent application Ser. No. 13/791,889, filed Mar. 8, 2013, by Paul V. Cooper, U.S. patent application Ser. No. 13/791,952, filed Mar. 9, 2013, by Paul V. Cooper, U.S. patent application Ser. No. 13/841,594, filed Mar. 15, 2013, by Paul V. Cooper, and U.S. patent application Ser. No. 14/027,237, filed Sep. 15, 2013, by Paul V. Cooper, U.S. Pat. No. 8,535,603 entitled ROTARY DEGASSER AND ROTOR THEREFOR, U.S. Pat. No. 8,613,884 entitled LAUNDER TRANSFER INSERT AND SYSTEM, U.S. Pat. No. 8,714,914 entitled MOLTEN METAL PUMP FILTER, U.S. Pat. No. 8,753,563 entitled SYSTEM AND METHOD FOR DEGASSING MOLTEN METAL, U.S. Pat. No. 9,011,761 entitled LADLE WITH TRANSFER CONDUIT, U.S. Pat. No. 9,017,597 entitled TRANSFERRING MOLTEN METAL USING NON-GRAVITY ASSIST LAUNDER, U.S. Pat. No. 9,034,244 entitled GAS-TRANSFER FOOT, U.S. Pat. No. 9,080,577 entitled SHAFT AND POST TENSIONING DEVICE, U.S. Pat. No. 9,108,244 entitled IMMERSION HEATHER FOR MOLTEN METAL, U.S. Pat. No. 9,156,087 entitled MOLTEN METAL TRANSFER SYSTEM AND ROTOR, U.S. Pat. No. 9,205,490 entitled TRANSFER WELL SYSTEM AND METHOD FOR MAKING SAME, U.S. Pat. No. 9,328,615 entitled ROTARY DEGASSERS AND COMPONENTS THEREFOR, U.S. Pat. No. 9,377,028 entitled TENSIONING DEVICE EXTENDING BEYOND COMPONENT, U.S. Pat. No. 9,382,599 entitled ROTARY DEGASSER AND ROTOR THEREFOR, U.S. Pat. No. 9,383,140 entitled TRANSFERRING MOLTEN METAL FROM ONE STRUCTURE TO ANOTHER, U.S. Pat. No. 9,409,232 entitled MOLTEN METAL TRANSFER VESSEL AND METHOD OF CONSTRUCTION, U.S. Pat. No. 9,410,744 entitled VESSEL TRANSFER INSERT AND SYSTEM, U.S. Pat. No. 9,422,942 entitled TENSION DEVICE WITH INTERNAL PASSAGE, U.S. Pat. No. 9,435,343 entitled GAS-TRANSFER FOOT, U.S. Pat. No. 9,464,636 entitled TENSION DEVICE GRAPHITE COMPONENT USED IN MOLTEN METAL, U.S. Pat. No. 9,470,239 THREADED TENSIONING DEVICE, U.S. Pat. No. 9,481,035 entitled IMMERSION HEATER FOR MOLTEN METAL, U.S. Pat. No. 9,482,469 entitled VESSEL TRANSFER INSERT AND SYSTEM, U.S. Pat. No. 9,506,129 entitled ROTARY DEGASSER AND ROTOR THEREFOR, U.S. Pat. No. 9,566,645 entitled MOLTEN METAL TRANSFER SYSTEM AND ROTOR, U.S. Pat. No. 9,581,388 entitled VESSEL TRANSFER INSERT AND SYS-

TEM, U.S. Pat. No. 9,587,883 entitled LADLE WITH TRANSFER CONDUIT, U.S. Pat. No. 9,643,247 entitled MOLTEN METAL TRANSFER AND DEGASSING SYSTEM, U.S. Pat. No. 9,657,578 entitled ROTARY DEGASSERS AND COMPONENTS THEREFOR, U.S. Pat. No. 9,855,600 entitled MOLTEN METAL TRANSFER SYSTEM AND ROTOR, U.S. Pat. No. 9,862,026 entitled METHOD OF FORMING TRANSFER WELL, U.S. Pat. No. 9,903,383 entitled MOLTEN METAL ROTOR WITH HARDENED TOP, U.S. Pat. No. 9,909,808 entitled SYSTEM AND METHOD FOR DEGASSING MOLTEN METAL, U.S. Pat. No. 9,925,587 entitled METHOD OF TRANSFERRING MOLTEN METAL FROM A VESSEL, entitled U.S. Pat. No. 9,982,945 MOLTEN METAL TRANSFER VESSEL AND METHOD OF CONSTRUCTION, U.S. Pat. No. 10,052,688 entitled TRANSFER PUMP LAUNDER SYSTEM, U.S. Pat. No. 10,072,891 entitled TRANSFERRING MOLTEN METAL USING NON-GRAVITY ASSIST LAUNDER, U.S. Pat. No. 10,126,058 entitled MOLTEN METAL TRANSFERRING VESSEL, U.S. Pat. No. 10,126,059 entitled CONTROLLED MOLTEN METAL FLOW FROM TRANSFER VESSEL, U.S. Pat. No. 10,138,892 entitled ROTOR AND ROTOR SHAFT FOR MOLTEN METAL, U.S. Pat. No. 10,195,664 entitled MULTI-STAGE IMPELLER FOR MOLTEN METAL, U.S. Pat. No. 10,267,314 entitled TENSIONED SUPPORT SHAFT AND OTHER MOLTEN METAL DEVICES, U.S. Pat. No. 10,274,256 entitled VESSEL TRANSFER SYSTEMS AND DEVICES, U.S. Pat. No. 10,302,361 entitled TRANSFER VESSEL FOR MOLTEN METAL PUMPING DEVICE, U.S. Pat. No. 10,309,725 entitled IMMERSION HEATER FOR MOLTEN METAL, U.S. Pat. No. 10,307,821 entitled TRANSFER PUMP LAUNDER SYSTEM, U.S. Pat. No. 10,322,451 entitled TRANSFER PUMP LAUNDER SYSTEM, U.S. Pat. No. 10,345,045 entitled VESSEL TRANSFER INSERT AND SYSTEM, U.S. Pat. No. 10,352,620 entitled TRANSFERRING MOLTEN METAL FROM ONE STRUCTURE TO ANOTHER, U.S. Pat. No. 10,428,821 entitled QUICK SUBMERGENCE MOLTEN METAL PUMP, U.S. Pat. No. 10,458,708 entitled TRANSFERRING MOLTEN METAL FROM ONE STRUCTURE TO ANOTHER, U.S. Pat. No. 10,465,688 entitled COUPLING AND ROTOR SHAFT FOR MOLTEN METAL DEVICES, U.S. Pat. No. 10,562,097 entitled MOLTEN METAL TRANSFER SYSTEM AND ROTOR, U.S. Pat. No. 10,570,745 entitled ROTARY DEGASSERS AND COMPONENTS THEREFOR, U.S. Pat. No. 10,641,279 entitled MOLTEN METAL ROTOR WITH HARDENED TIP, U.S. Pat. No. 10,641,270 entitled TENSIONED SUPPORT SHAFT AND OTHER MOLTEN METAL DEVICES, and U.S. patent application Ser. Nos. 16/877,267, 16/877,364, 16/877,296, 16/877,332, and 16/877,182, entitled MOLTEN METAL CONTROLLED FLOW LAUNDER, MOLTEN METAL TRANSFER SYSTEM AND METHOD, SYSTEM AND METHOD TO FEED MOLD WITH MOLTEN METAL, SMART MOLTEN METAL PUMP, and SYSTEM FOR MELTING SOLID METAL, all of which were filed on the same date as this Application.

Three basic types of pumps for pumping molten metal, such as molten aluminum, are utilized: circulation pumps, transfer pumps and gas-release pumps. Circulation pumps are used to circulate the molten metal within a bath, thereby generally equalizing the temperature of the molten metal. Circulation pumps may be used in any vessel, such as in a reverbatory furnace having an external well. The well is usually an extension of the charging well, in which scrap metal is charged (i.e., added).

Standard transfer pumps are generally used to transfer molten metal from one structure to another structure such as a ladle or another furnace. A standard transfer pump has a riser tube connected to a pump discharge and supported by the superstructure. As molten metal is pumped it is pushed up the riser tube (sometimes called a metal-transfer conduit) and out of the riser tube, which generally has an elbow at its upper end, so molten metal is released into a different vessel from which the pump is positioned.

Gas-release pumps, such as gas-injection pumps, circulate molten metal while introducing a gas into the molten metal. In the purification of molten metals, particularly aluminum, it is frequently desired to remove dissolved gases such as hydrogen, or dissolved metals, such as magnesium. As is known by those skilled in the art, the removing of dissolved gas is known as "degassing" while the removal of magnesium is known as "demagging." Gas-release pumps may be used for either of both of these purposes or for any other application for which it is desirable to introduce gas into molten metal.

Gas-release pumps generally include a gas-transfer conduit having a first end that is connected to a gas source and a second end submerged in the molten metal bath. Gas is introduced into the first end and is released from the second end into the molten metal. The gas may be released downstream of the pump chamber into either the pump discharge or a metal-transfer conduit extending from the discharge, or into a stream of molten metal exiting either the discharge or the metal-transfer conduit. Alternatively, gas may be released into the pump chamber or upstream of the pump chamber at a position where molten metal enters the pump chamber. The gas may also be released into any suitable location in a molten metal bath.

Molten metal pump casings and rotors often employ a bearing system comprising ceramic rings wherein there are one or more rings on the rotor that align with rings in the pump chamber (such as rings at the inlet and outlet) when the rotor is placed in the pump chamber. The purpose of the bearing system is to reduce damage to the soft, graphite components, particularly the rotor and pump base, during pump operation.

Generally, a degasser (also called a rotary degasser) includes (1) an impeller shaft having a first end, a second end and a passage for transferring gas, (2) an impeller, and (3) a drive source for rotating the impeller shaft and the impeller. The first end of the impeller shaft is connected to the drive source and to a gas source and the second end is connected to the impeller.

Generally a scrap melter includes an impeller affixed to an end of a drive shaft, and a drive source attached to the other end of the drive shaft for rotating the shaft and the impeller. The movement of the impeller draws molten metal and scrap metal downward into the molten metal bath in order to melt the scrap. A circulation pump is preferably used in conjunction with the scrap melter to circulate the molten metal in order to maintain a relatively constant temperature within the molten metal.

The materials forming the components that contact the molten metal bath should remain relatively stable in the bath. Structural refractory materials, such as graphite or ceramics, that are resistant to disintegration by corrosive attack from the molten metal may be used. As used herein "ceramics" or "ceramic" refers to any oxidized metal (including silicon) or carbon-based material, excluding graphite, or other ceramic material capable of being used in the environment of a molten metal bath. "Graphite" means any type of graphite, whether or not chemically treated. Graphite is particularly suitable for being formed into pump components because it is (a) soft and relatively easy to machine, (b) not as brittle as ceramics and less prone to breakage, and (c) less expensive than ceramics.

Ceramic, however, is more resistant to corrosion by molten aluminum than graphite. It would therefore be advantageous to develop vertical members used in a molten metal device that are comprised of ceramic, but less costly than solid ceramic members, and less prone to breakage than normal ceramic.

SUMMARY OF THE INVENTION

A scrap melting system and method includes a vessel that is configured to retain molten metal and a raised surface about the level of molten metal in the vessel. Solid metal is placed on the raised surface and molten metal from the vessel is moved upward from the vessel and across the raised surface to melt at least some of the metal. The molten metal is preferably raised from the vessel to the raised surface by a molten metal pumping device or system. The molten metal moves off of the raised surface and into a vessel of any suitable type, or launder. Any suitable method for moving molten metal onto the raised surface may be used, and the claims are not limited to the exemplary embodiments disclosed herein.

One exemplary embodiment of a system for transferring molten metal onto a raised surface comprises at least (1) a vessel for retaining molten metal, (2) a dividing wall (or overflow wall) within the vessel, the dividing wall having a height H**1** and dividing the vessel into at least a first chamber and a second chamber, and (3) a molten metal pump in the vessel, preferably in the first chamber. The system may also include other devices and structures such as one or more of a launder, a third chamber, an additional vessel, a rotary degasser, one or more additional pumps, and a pump control system.

In one embodiment, the second chamber has a wall or opening with a height H**2** that is lower than height H**1** and the second chamber is juxtaposed the raised surface. The pump (either a transfer, circulation or gas-release pump) is submerged in the first chamber (preferably) and pumps molten metal from the first chamber past the dividing wall and into the second chamber causing the level of molten metal in the second chamber to rise. When the level of molten metal in the second chamber exceeds height H**2**, molten metal flows out of the second chamber and onto the raised surface onto which solid metal, such as scrap aluminum, has been placed. If a circulation pump, which is most preferred, or a gas-release pump is utilized, the molten metal would be pumped through the pump discharge and through an opening in the dividing wall wherein the opening is preferably completely below the surface of the molten metal in the first chamber.

In addition, preferably the pump used to transfer molten metal from the first chamber to the second chamber is a circulation pump (most preferred) or gas-release pump, preferably a variable speed pump. When utilizing such a pump there is an opening in the dividing wall beneath the level of molten metal in the first chamber during normal operation. The pump discharge communicates with, and may be received partially or totally in the opening. When the pump is operated it pumps molten metal through the opening and into the second chamber thereby raising the level in the second chamber until the level surpasses H**2** and flows out of the second chamber.

Further, if the pump is a variable speed pump, which is preferred, a control system may be used to speed or slow the pump, either manually or automatically, as the amount of scrap to the melted, or remaining to be melted, varies.

Utilizing such a variable speed circulation pump or gas-release pump further reduces the chance of splashing and formation or dross, and reduces the chance of lags in which there is no molten metal being transferred or that could cause a device, such as a ladle, to be over filled. It leads to even and controlled transfer of molten metal from the vessel into another device or structure.

The problems with splashing or turbulence, or a difficult to control molten metal flow, are greatly reduced or eliminated by utilizing this system. Molten metal can be smoothly flowed across the raised surface and the level of molten metal raised or lowered as desired to melt the scrap on the raised surface. As solid metal is melted and becomes part of the molten (or liquid) metal, this melt (which includes the original molten metal and the melted, former solid metal) flows past the back, or second, side of the raised surface. From there the melt may enter any suitable structure, such as a launder, another vessel, or another chamber of the same vessel in which the molten metal pump and dividing wall are positioned. The melt may be degassed, such as by a rotary degasser, pumped, or demagged, such as by using a gas-release pump that releases chlorine gas into the melt.

Preferably, before or after the melt moves off the raised surface it is filtered to remove at least some solid particles. The filtering can be done by a grate positioned near or at the rear side of the raised surface. Solid particles that remain on the raised surface are removed, such as by using a steel arm that is lowered onto the raised surface and pulled across the surface to remove the solid particles.

Although one specific system is disclosed herein for raising molten metal to flow across the raised surface, and suitable system, method, or device may be utilized to move molten metal across the raised surface with little splashing or turbulence, and to evenly control the flow across the entire raised surface on which the solid metal is positioned.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional side view of a system according to this disclosure for melting solid metal on a raised surface.

FIG. **1**A is a cross-sectional side view of a system according to this disclosure for melting solid metal on a raised surface and that includes one or more side walls.

FIG. **2** is the system of FIG. **1** showing the level of molten metal in the furnace being increased.

FIG. **2**A shows the system of FIG. **1** with side walls on the raised surface that help contain the molten metal.

FIG. **2**B shows the system of FIGS. **1** and **2** and displays how heights H**1** and H**2** are determined.

FIG. **3** is a top, partial cross-sectional view of the system of FIG. **2**A.

FIG. **3**A is a partial, cross-sectional side view of a system according to this disclosure.

FIG. **4** is a partial, cross-sectional side view of a system according to this disclosure that is utilized to fill a ladle.

FIG. **5** is a partial, cross-sectional side view of an alternate embodiment of the present disclosure.

FIG. **6** is a partial cross-sectional, side view of an embodiment of this disclosure.

FIG. **7** is a top, partial cross-sectional view of the embodiment of FIG. **6** with a pump.

FIG. **8** is a partial side, cross-sectional view of the system of FIG. **6**.

FIG. **9** is a partial perspective, side view of a system according to this disclosure.

FIG. **10** is a cross-sectional, side view of an embodiment of this disclosure that further includes a launder.

FIG. **11** is a cross-sectional, side view of an embodiment of this disclosure that further includes an additional vessel or chamber.

FIG. **12** is a side, cross-sectional view of an alternate system of this disclosure that includes an additional vessel or chamber that has a molten metal pump.

FIG. **13** is a side, cross-sectional view of an alternate system of this disclosure that includes an additional vessel or chamber that has a rotary degasser.

DETAILED DESCRIPTION

Turning now to the Figures, where the purpose is to describe preferred embodiments of the invention and not to limit same, FIGS. **1-3**A show a system **10** for moving molten metal M onto a raised surface **20** in order to melt solid metal, such as aluminum scrap. System **10** includes a furnace **1** that can retain molten metal M, which includes a holding furnace **1**A, a vessel **12**, a raised surface **20**, and a pump **22**. System **10** preferably has a vessel **12**, a dividing wall **14** to separate vessel **12** into at least a first chamber **16** and a second chamber **18**, and a device or structure, which may be pump **22**, for generating a stream of molten metal from first chamber **16** into second chamber **18**.

Using heating elements (not shown in the figures), furnace **1** is raised to a temperature sufficient to maintain the metal therein (usually aluminum or zinc) in a molten state. The level of molten metal M in holding furnace **1**A and in at least part of vessel **12** changes as metal is added or removed to furnace **1**A, as can be seen in FIGS. **2** and **11**.

For explanation, furnace **1** includes a furnace wall **2** having an archway **3**. Archway **3** allows molten metal M to flow into vessel **12** from holding furnace **1**A. In this embodiment, furnace **1**A and vessel **12** are in fluid communication, so when the level of molten metal in furnace **1**A rises, the level also rises in at least part of vessel **12**. It most preferably rises and falls in first chamber **16**, described below, as the level of molten metal rises or falls in furnace **1**A. This can be seen in FIGS. **2** and **11**.

Dividing wall **14** separates vessel **12** into at least two chambers, a pump well (or first chamber) **16** and a skim well (or second chamber) **18**, and any suitable structure for this purpose may be used as dividing wall **14**. As shown in this embodiment, dividing wall **14** has an opening **14**A and an optional overflow spillway **14**B (best seen in FIG. **3**), which is a notch or cut out in the upper edge of dividing wall **14**. Overflow spillway **14**B is any structure suitable to allow molten metal to flow from second chamber **18**, past dividing wall **14**, and into first chamber **16** and, if used, overflow spillway **14**B may be positioned at any suitable location on wall **14**. The purpose of optional overflow spillway **14**B is to prevent molten metal from overflowing the second chamber **18**, or a launder in communication with second chamber **18** (if a launder is used with the invention), by allowing molten metal in second chamber **18** to flow back into first chamber **16**. Optional overflow spillway **14**B would not be utilized during normal operation of system **10** and is to be used as a safeguard if the level of molten metal in second chamber **18** improperly rises to too high a level.

At least part of dividing wall **14** has a height H**1** (best seen in FIG. **2**A), which is the height at which, if exceeded by molten metal in second chamber **18**, molten metal flows past the portion of dividing wall **14** at height H**1** and back into first chamber **16**. In the embodiment shown in FIGS. **1-3**A, overflow spillway **14**B has a height H**1** and the rest of dividing wall **14** has a height greater than H**1**. Alternatively, dividing wall **14** may not have an overflow spillway, in which case all of dividing wall **14** could have a height H**1**, or dividing wall **14** may have an opening with a lower edge positioned at height H**1**, in which case molten metal could flow through the opening if the level of molten metal in second chamber **18** exceeded H**1**. H**1** should exceed the highest level of molten metal in first chamber **16** during normal operation.

Second chamber **18** has a portion **18**A, which has a height H**2**, wherein H**2** is less than H**1** (as can be best seen in FIG. **2**A) so during normal operation molten metal pumped into second chamber **18** flows past wall **18**A and out of second chamber **18** rather than flowing back over dividing wall **14** and into first chamber **16**.

Dividing wall **14** may also have an opening **14**A that is located at a depth such that opening **14**A is submerged within the molten metal during normal usage, and opening **14**A is preferably near or at the bottom of dividing wall **14**. Opening **14**A preferably has an area of between 6 $in.^2$ and 24 $in.^2$, but could be any suitable size. Further, dividing wall **14** need not have an opening if a transfer pump were used to transfer molten metal from first chamber **16**, over the top of wall **14**, and into second chamber **18** as described below.

Dividing wall **14** may also include more than one opening between first chamber **16** and second chamber **18** and opening **14**A (or the more than one opening) could be positioned at any suitable location(s) in dividing wall **14** and be of any size(s) or shape(s) to enable molten metal to pass from first chamber **16** into second chamber **18**.

Molten metal pump **22** may be any device or structure capable of pumping or otherwise conveying molten metal, and may be a transfer, circulation or gas-release pump. Pump **22** is preferably a circulation pump (most preferred) or gas-release pump that generates a flow of molten metal from first chamber **16** to second chamber **18** through opening **14**A. Pump **22** generally includes a motor **24** surrounded by a cooling shroud **26**, a superstructure **28**, support posts **30** and a base **32**. Some pumps that may be used with the invention are shown in U.S. Pat. Nos. 5,203,681, 6,123,523 and 6,354,964 to Cooper, and pending U.S. application Ser. No. 10/773,101 to Cooper. Molten metal pump **22** can be a constant speed pump, but is most preferably a variable speed pump. Its speed can be varied depending on the amount of molten metal in a structure such as a ladle or launder, as discussed below.

Utilizing system **10**, as pump **22** pumps molten metal from first chamber **16** into second chamber **18**, the level of molten metal in chamber **18** rises. When a pump with a discharge submerged in the molten metal bath, such as circulation pump or gas-release pump is utilized, there is essentially no turbulence or splashing during this process, which reduces the formation of dross and reduces safety hazards. The flow of molten metal is smooth and generally at an even flow rate.

A system according to this disclosure could also include one or more pumps in addition to pump **22**, in which case the additional pump(s) may circulate molten metal within first chamber **16** and/or second chamber **18**, or from chamber **16** to chamber **18**, and/or may release gas into the molten metal first in first chamber **16** or second chamber **18**. For example, first chamber **16** could include pump **22** and a second pump, such as a circulation pump or gas-release pump, to circulate and/or release gas into molten metal M.

If pump **22** is a circulation pump or gas-release pump, it is at least partially received in opening **14**A in order to at least partially block opening **14**A in order to maintain a relatively stable level of molten metal in second chamber **18** during normal operation and to allow the level in second chamber **18** to rise independently of the level in first chamber **16**. Utilizing this system the movement of molten metal from one chamber to another and from the second chamber into a launder does not involve raising molten metal above the molten metal surface. As previously mentioned this alleviates problems with blockage forming (because of the molten metal cooling and solidifying), and with turbulence and splashing, which can cause dross formation and safety problems. As shown, part of base **32** (preferably the discharge portion of the base) is received in opening **14**A. Further, pump **22** may communicate with another structure, such as a metal-transfer conduit, that leads to and is received partially or fully in opening **14**A. Although it is preferred that the pump base, or communicating structure such as a metal-transfer conduit, be received in opening **14**A, all that is necessary for the invention to function is that the operation of the pump increases and maintains the level of molten metal in second chamber **18** so that the molten metal ultimately moves out of chamber **18** and into another structure. For example, the base of pump **22** may be positioned so that its discharge is not received in opening **14**A, but is close enough to opening **14**A that the operation of the pump raises the level of molten metal in second chamber **18** independent of the level in chamber **16** and causes molten metal to move out of second chamber **18** and into another structure. A sealant, such as cement (which is known to those skilled in the art), may be used to seal base **32** into opening **14**A, although it is preferred that a sealant not be used.

A system according to this disclosure could also be operated with a transfer pump, although a pump with a submerged discharge, such as a circulation pump or gas-release pump, is preferred since either would be less likely to create turbulence and dross in second chamber **18**, and neither raises the molten metal above the surface of the molten metal bath nor has the other drawbacks associated with transfer pumps that have previously been described. If a transfer pump were used to move molten metal from first chamber **16**, over dividing wall **14**, and into second chamber **18**, there would be no need for opening **14**A in dividing wall **14**, although an opening could still be provided and used in conjunction with an additional circulation or gas-release pump. As previously described, regardless of what type of pump is used to move molten metal from first chamber **16** to second chamber **18**, molten metal would ultimately move out of chamber **18** and into a structure, such as ladle **52** or launder **20**, when the level of molten metal in second chamber **18** exceeds H**2**.

Once pump **22** is turned off, the respective levels of molten metal level in chambers **16** and **18** essentially equalize. Alternatively, the speed of pump **22** could be reduced to a relatively low speed to keep the level of molten metal in second chamber **18** relatively constant but not exceed height H**2**. To move molten metal onto raised surface **20**, pump **22** is simply turned on again and operated as described above.

A system for melting scrap according to this disclosure includes a molten metal pump and a raised surface **20** on which solid metal S, such as scrap aluminum, can be positioned, wherein molten metal is flowed onto and across the raised surface **20** in order to melt at least some of the solid metal S. As described above, the pump **22** generates a flow of molten metal M from first chamber **16** into second chamber **18**. When the level of molten metal M in second chamber **18** exceeds H**2**, the molten metal moves out of second chamber **18** and onto the raised surface **20** to melt scrap placed on surface **20**. The level of molten metal M in the second chamber **18** rises until it flows onto raised surface **20**, and flows along the raised surface **20** until it melts at least some of the solid metal S on the raised surface **20** melts. The amount of molten metal flowed across raised surface **20** can be varied based on any suitable factor, such as based on the amount of solid metal S on raised surface **20**.

The raised surface **20** has a first side **20**A adjacent the second chamber **18** and a second side **20**B. Raised surface **20** can be the upper surface of a refractory block **23**, which may be inside or outside of vessel **1**. A refractory grate **75** is preferably positioned at, or just before or just after, second side **20**B. The refractory grate **75** acts as a filter that blocks pieces of unmelted metal, such as pieces of iron or steel, from being mixed with the molten metal M and moving off of raised surface **20**. Any suitable filter could be used for this purpose.

Preferably, before or after the melt moves off the raised surface **20** it is filtered to remove at least some solid particles. The filtering can be done by grate **75**. Solid particles, such as iron or steel, that remain on the raised surface **20** are removed, such as by using a steel arm that is lowered onto the raised surface **20** and pulled across the raised surface **20** to remove the solid particles. The method of adding solid metal S and melting it can then be repeated.

The raised surface **20** may also include one or more side walls **29** (as shown, for example, in FIG. **1**A) that help retain molten metal on the raised surface.

The molten metal M could pass from the raised surface **20** into another vessel or chamber **2000**, or move into a launder **31** (as shown in FIG. **10**) or any suitable structure.

Furthermore, molten metal can be moved across the raised surface **20** in any suitable manner, such as by using pumping and transfer devices incorporated by reference herein. The specific system described herein using a dividing wall, however, is most preferred because the flow of molten metal can be carefully controlled and spread over a large area, in order to cover the width of the raised surface **20** or a large portion of the width of the raised surface **20**.

Although one specific system is disclosed herein for raising molten metal to flow across the raised surface, and suitable system, method, or device may be utilized to move molten metal across the raised surface with little splashing or turbulence, and to evenly control the flow across the entire raised surface on which the solid metal is positioned.

The problems with splashing or turbulence, or a difficult to control molten metal flow, are greatly reduced or eliminated by utilizing this system. Molten metal M can be smoothly flowed across the raised surface **20** and the level of molten metal M raised or lowered as desired to melt the solid metal S on the raised surface **20**. As solid metal S is melted and becomes part of the molten (or liquid) metal, this melt (which includes the original molten metal and the melted, former solid metal) flows past the back, or second, side **20**B of the raised surface **20**. From there the melt may enter any suitable structure, such as a launder **31**, another vessel, or another chamber of the same vessel, **2000** in which the molten metal pump and dividing wall are positioned. The melt may be degassed, such as by a rotary degasser, pumped, or demagged, such as by using a gas-release pump that releases chlorine gas into the melt.

As shown in FIG. **10**, launder **31** is any structure or device for transferring molten metal from raised surface **20** to one or more structures, such as one or more ladles, molds (such as ingot molds) or other structures in which the molten metal is ultimately cast into a usable form, such as an ingot. Launder **31** may be either an open or enclosed channel, trough or conduit and may be of any suitable dimension or length, such as one to four feet long, or as much as 100 feet long or longer. Launder **31** may be completely horizontal or may slope gently upward or downward. Launder **31** may have one or more taps (not shown), i.e., small openings stopped by removable plugs. Each tap, when unstopped, allows molten metal to flow through the tap into a ladle, ingot mold, or other structure. Launder **31** may additionally or alternatively be serviced by robots or cast machines capable of removing molten metal M from launder **31**.

Launder **31** has a first end **31**A juxtaposed the second end **20**B of raised surface **20** and a second end **31**B that is opposite first end **31**B. An optional stop may be included in a launder according to the invention. The stop, if used, is preferably juxtaposed the second end **31**B of the launder. If launder **31** has a stop, the stop can be opened to allow molten metal to flow past end **31**B, or closed to prevent molten metal from flowing past end **31**B. The stop preferably has a height H**3** greater than height H**1** so that if launder **31** becomes too filled with molten metal, the molten metal would back up on raised surface **20**, and spill back over dividing wall **14**A (over spillway **14**B, if used) rather than overflow raised surface **20** and launder **31**.

FIG. **4** shows an alternate system **10'** that is in all respects the same as system **10** except that it has a shorter, downward, sloping surface **20'** for retaining solid metal to be melted, a wall **18**A' past which molten metal moves when it exits second chamber **18** and it fills a ladle **52**.

FIG. **12** shows an alternate system **10** that is in all respects the same as system **10** except that it includes an optional second pump **1500** in a third chamber, or second vessel, **2000** having a basin **2012**.

FIG. **13** shows an alternate system **10**A' that is in all respects the same as system **10** except that it includes an optional rotary degasser **110** in a third chamber, or second vessel, **2000** having a basin **2012**.

Some non-limiting examples of this disclosure are as follows:

Example 1: A method for melting solid aluminum utilizing a system that comprises:

a vessel having a first chamber, a second chamber, and a raised surface;

a molten metal pump in the first vessel;

a first dividing wall between the first chamber and second chamber, the first dividing wall having a first height, and an opening that is beneath the height; and

a second dividing wall between the second chamber and a raised surface, the second dividing wall having a second height that is less than the first height;

wherein the method comprises the following steps:

placing solid aluminum on the raised surface; and

operating the pump to move molten metal through the opening in the first dividing wall, so that the molten metal exceeds the second height and flows across the raised surface until at least some of the solid aluminum is melted into melted aluminum.

Example 2: The method of claim **1**, wherein the system further comprises a grate at the rear side of the raised surface, and a melt comprising at least most of the molten metal and melted aluminum passes through the grate.

Example 3: The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a launder.

Example 4: The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a third chamber.

Example 5: The method of claim **1** that further includes the step of stopping the flow of molten metal across the raised surface after at least some of the solid aluminum on the surface is melted.

Example 6: The method of claim **1** that further includes the step of removing unmelted pieces of metal from the raises surface.

Example 7: The method of claim **5** that further includes the step of removing unmelted pieces of metal from the raised surface after stopping the flow of molten metal across the raised surface.

Example 8: The method of claim **4** that further includes the step of pumping the molten metal in the third chamber.

Example 9: The method of claim **4** that further includes the step of degassing the molten metal in the third chamber.

Example 10: The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a third chamber.

Example 11: The method of claim **1** that further includes the step of stopping the flow of molten metal across the raised surface after at least some of the solid aluminum on the surface is melted.

Example 12: The method of claim **1** that further includes the step of removing unmelted pieces of metal from the raises surface.

Example 13: A method of melting metal scrap, Example 1: The method comprising the steps of:

placing solid metal on a raised surface, wherein the surface will not melt at the melting temperature of the solid metal;

moving molten metal across the raised surface in order to melt at least some of the solid metal; and

removing solid pieces that did not melt from the raised surface.

Example 14: The method of claim **13**, wherein the solid metal and liquid metal are the same metal.

Example 15: The method of claim **13**, wherein the solid metal and liquid metal are both aluminum.

Example 16: The method of claim **13** that further includes the step of not moving molten metal across the raised surface after at least some of the solid metal has been melted.

Example 17: The method of claim **13** that further includes the step of filtering the melt.

Example 18: The method of claim **13** that further includes the step of filtering the melt before it moves off the raised surface.

Example 19: The method of claim **13** that further includes the step of moving the molten metal into either a launder or a vessel after it moves past the raised surface.

Example 20: The method of claim **13** that further includes the step of moving the molten metal into a vessel and pumping the molten metal.

Example 21: The method of claim **13** that further includes the step of moving the molten metal from the raised surface and into a third chamber.

Example 22: The method of claim **13** that further includes the step of stopping the flow of molten metal across the raised surface after at least some of the solid aluminum on the surface is melted.

Example 23: The method of claim **13** that further includes the step of removing unmelted pieces of metal from the raised surface.

Example 24: The method of claim **1** wherein the pumping is not continuous.

Example 25: The method of claim **1** wherein the pumping is performed by a transfer pump.

Example 26: The method of claim **1** wherein the pumping is performed by a circulation pump.

Example 27: The method of claim **1** wherein the pumping is performed by a gas-release pump.

Example 28: The method of claim **1** wherein the dividing wall has an opening to permit molten metal to be pumped from the first chamber through the opening and into the second chamber.

Example 29: The method of example 28, wherein the pump has a pump base and a discharge, and the dividing wall has an opening to permit molten metal to be pumped from the first chamber through the opening and into the second chamber, the discharge being aligned with the opening so that at least some of the molten metal exiting the discharge passes through the opening.

Example 30: The method of claim **1** wherein the pumping is performed at a speed, and the speed is variable.

Example 31: The method of claim **1** wherein the pumping is performed at a speed, and the speed is constant.

Having thus described different embodiments of the invention, other variations and embodiments that do not depart from the spirit thereof will become apparent to those skilled in the art. The scope of the present invention is thus not limited to any particular embodiment, but is instead set forth in the appended claims and the legal equivalents thereof. Unless expressly stated in the written description or claims, the steps of any method recited in the claims may be performed in any order capable of yielding the desired product or result.

What is claimed is:

1. A method for melting solid aluminum utilizing a system that comprises:

(a) a vessel having a first chamber, a second chamber, and a raised surface;

(b) a molten metal pump in the vessel;

(c) a first dividing wall between the first chamber and second chamber, the first dividing wall having a first height, and an opening that is beneath the height; and

(d) a second dividing wall between the second chamber and the raised surface, the second dividing wall having a second height that is less than the first height;

wherein the method comprises the following steps:

(e) placing solid aluminum on the raised surface; and

(f) operating the pump to move molten metal through the opening in the first dividing wall, so that the molten metal exceeds the second height and flows across the raised surface until at least some of the solid aluminum is melted into melted aluminum.

2. The method of claim **1**, wherein the system further comprises a grate on the raised surface, and the method further comprises the step of a melt comprising at least most of the molten metal and melted aluminum passing through the grate.

3. The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a launder.

4. The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a third chamber.

5. The method of claim **1** that further includes the step of stopping the flow of molten metal across the raised surface after at least some of the solid aluminum on the raised surface is melted.

6. The method of claim **1** that further includes the step of removing unmelted pieces of metal from the raised surface.

7. The method of claim **5** that further includes the step of removing unmelted pieces of metal from the raised surface after stopping the flow of molten metal across the raised surface.

8. The method of claim **4** that further includes the step of pumping the molten metal in the third chamber.

9. The method of claim **4** that further includes the step of degassing the molten metal in the third chamber.

10. The method of claim **1** that further includes the step of moving the molten metal from the raised surface and into a third chamber.

11. The method of claim **1** that further includes the step of stopping the flow of molten metal across the raised surface after at least some of the solid aluminum on the surface is melted.

12. The method of claim **1** that further includes the step of removing unmelted pieces of metal from the raised surface.

13. The method of claim **1**, wherein the pumping is not continuous.

14. The method of claim **1**, wherein the pumping is performed by a transfer pump.

15. The method of claim **1**, wherein the pumping is performed by a circulation pump.

16. The method of claim **1**, wherein the pumping is performed by a gas-release pump.

17. The method of claim **1**, wherein the dividing wall has an opening to permit molten metal to be pumped from the first chamber through the opening and into the second chamber.

18. The method of claim **17**, wherein the pump has a pump base and a discharge, and the dividing wall has an opening to permit molten metal to be pumped from the first chamber through the opening and into the second chamber, the discharge being aligned with the opening so that at least some of the molten metal exiting the discharge passes through the opening.

19. The method of claim **1**, wherein the pumping is performed at a speed, and the speed is variable.

20. The method of claim **1**, wherein the pumping is performed at a speed, and the speed is constant.

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